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Vol. 45 No. 1 SPRING, 1994

TABLE OF CONTENTS PAGE

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Gene Flow Among Island Populations of Marsh Rice Rats (*Oryzomys palustris*)

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ABSTRACT

Inter-island movement data and allelic frequencies were compared to assess the differences between direct and indirect estimates of gene flow for marsh rice rats on the Virginia barrier islands. Inter-island movements among four adjacent islands and the mainland were observed during the summer of 1989. Ten movements between two islands separated by 50 m and one movement between two islands separated by 300 m were documented. The direct estimate of dispersal for the five sites was 0.75 migrants per generation. Electrophoretic variation in proteins encoded by 13 presumptive gene loci was analyzed using blood samples collected from rats trapped at the five sites. The indirect estimate of migration using Wright's F_{ST} method was 0.09 migrants per generation. The differences in the direct and indirect estimates may be due to sampling error, lack of successful reproduction by the immigrants, or to differences in the time scales that the direct and indirect methods represent.

Key words: gene flow, genetic differentiation, *Oryzomys palustris*

INTRODUCTION

Populations of small mammals on islands are well suited to study genetic differentiation (Calhoun and Greenbaum, 1991; Navarro and Britton-Davidian, 1989; Hanski and Kuitunen, 1986; Gill, 1980; Berry et al., 1978). Genetic differentiation is generally estimated by measuring morphologic and/or or biochemical variation and then population patterns are interpreted using theories on natural selection, mutation, genetic drift and gene flow. Although biogeographical information and data on the biology of the species aid in these interpretations, few studies (Ehrlich and Raven, 1969) have attempted to combine the genetic data with data on individual movements.

Gene flow within a species determines the extent to which genetic changes in local populations are independent (Slatkin, 1985a). Gene flow can be measured using both direct and indirect methods (Slatkin, 1985b, 1987). Direct methods, which use estimates of dispersal and breeding success of dispersers to infer gene flow, are biased in that they are limited in their duration and geographic extent. They also do not necessarily represent historical patterns of gene flow. Indirect methods use estimates of genetic variation, generally from biochemical procedures.

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Two methods of indirectly measuring gene flow are commonly used: Wright's statistic (F_{ST}) for estimating the standardized variation in allele frequencies among local populations (Wright, 1951) and Slatkin's rare alleles method (Slatkin, 1985b). The main problem associated with these indirect methods is that both are sensitive to variation in population structure.

The purpose of this study was to compare estimates of gene flow using direct and indirect methods for island populations of marsh rice rats (*Oryzomys palustris*), and to examine inter-island variation in allozymes. The marsh rice rat is a semi-aquatic rodent that inhabits salt marshes south of Maryland. Previous studies determined that this species inhabits more islands than any other small mammal on the Virginia barrier islands (Dueser and Porter, 1986). It has been hypothesized that the ability of the marsh rice rat to disperse across water is responsible for its ubiquity (Humphrey and Setzer, 1989).

METHODS

This study was conducted in 1989 at the Virginia Coast Reserve Long-Term Ecological Research site on the Virginia barrier islands. The barrier islands are a Holocene formation on the seaward margin of the Delmarva Peninsula. Four islands (Hog, Parramore, Revel, and Crescent) and the adjacent mainland marsh (near the town of Brownsville) were chosen due to their accessibility and proximity to each other (Figure 1). Parramore (2,197 ha in 1989) and Hog Island (1,177 ha in 1989) are barrier islands, and Revel (508 ha in 1989) is a bayside island. At the time of this study, Crescent was a small (10.0 ha) distinct island formed during the previous 20 years by sand accretion and inlet formation. Parramore and Crescent were separated by a 50 m water channel that ranged between 2-5 m deep. In October 1991, after this study was completed, a storm caused the channel separating Parramore and Crescent islands to fill with sand. The channel between Revel and Crescent is 300 m of deep water, and Hog and Parramore are separated by more than 1 km of deep water. The marsh near Brownsville is nearly equidistant from Hog and Parramore Islands. The vegetation of the four islands and mainland marsh differs slightly, but all support extensive *Spartina alterniflora* marsh, which is important rice rat habitat (McCaffrey and Dueser, 1990; Dueser and Porter, 1986)

To directly monitor inter-island movements of rice rats, determine the fate of inter-island movers, and estimate population density, trapping grids with Sherman live-traps spaced 15 m apart were laid in areas that were closest to adjacent islands. On the small island of Crescent and the narrow peninsulas of Parramore and Revel, a grid design of 6 by 20 traps was chosen because it covered the entire extent of Crescent Island and covered the width of the narrow peninsulas. On Hog and Brownsville, traps were laid in two long transects in an attempt to cover the extent of the marsh closest to the other islands. Each transect was 885 m long, and the two transects were spaced approximately 30 m apart. These transects covered approximately the same area as the island grids.

Trapping occurred May 20 through August 24, 1989. All small mammals caught were ear-tagged and examined for weight, sex, and reproductive condition, e. g., gravid, sexually active (males, testes descended; females, vagina perforate). During the first trapping session on Crescent Island, total enumeration and tagging of all *O. palustris* was attempted. Trapping continued until no untagged animals were

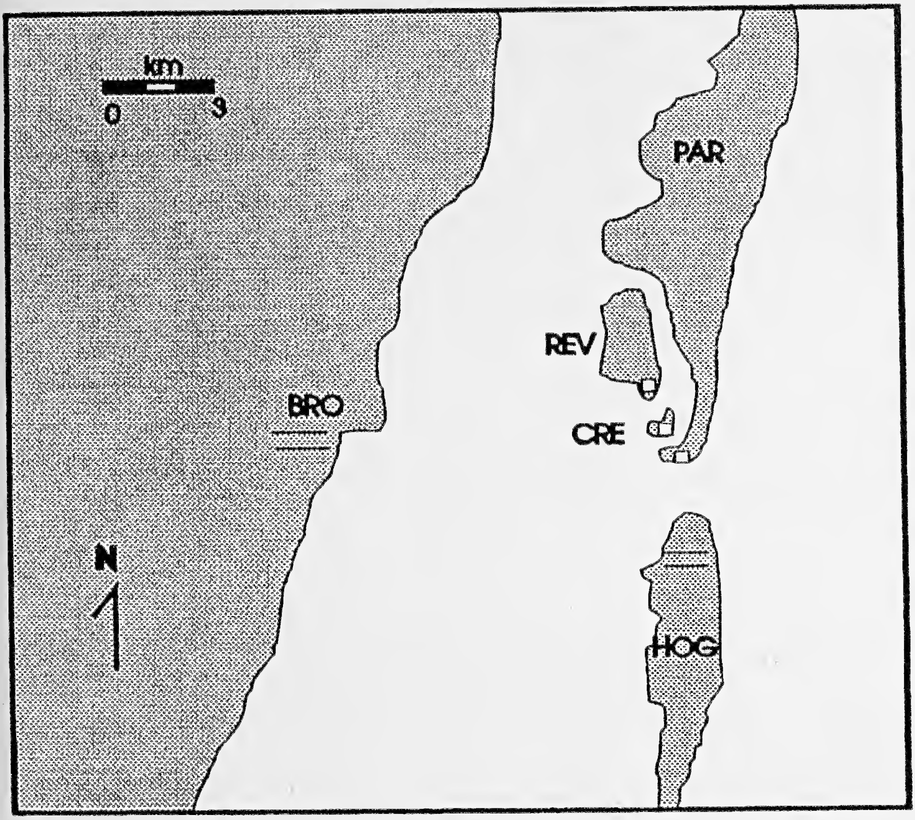

FIGURE 1. The study sites, four islands of the Virginia Barrier Island formation (PAR = Parramore, CRE = Crescent, REV = Revel, and HOG = Hog) and the mainland (BRO = Brownsville), as they appeared in 1989. The squares represent grids and the lines represent transects.

caught for three consecutive days, creating an 8-day trapping session. The individuals tagged were assumed to be residents of Crescent Island. Three of the islands (Parramore, Revel, and Crescent) and the mainland were trapped monthly (June, July, August) using the 8-day trapping session. The Hog Island site was trapped monthly using a comparable trapping session. Density was estimated using the minimum number alive method (MNA; Hilborn et al., 1976). MNA was chosen because it only considers the number of animals caught during each trapping session, allowing a comparison of the number of tagged rice rats that moved among islands to be made. Because it was difficult to differentiate between inter-island dispersers and juveniles born on the island, inter-island dispersers were defined as those animals previously tagged which moved to another island. Age was estimated using a weight proxy, with juveniles <30 g, subadults 30-50 g, and adults >50 g (Negus et al., 1961).

To indirectly estimate gene flow, allozymes were analyzed using blood samples (< 1 mL) taken from the tails of all the marsh rice rats (> 20 g) caught on the grids of Crescent, Parramore, and Revel and on the transects of Hog and Brownsville. Animals were transported to the laboratory, bled, and held overnight with food and water *ad libidum*. The next day each individual was released on the grid or transect from which it had been removed. Each animal was bled only once. Blood was stored in capillary tubes at -20°C and analyzed electrophoretically within one year.

Allozymes for 13 presumptive genetic loci were examined for 109 individuals from the five sites; 28 individuals each from Crescent and Revel, 8 individuals from Parramore, 25 rice rats from Hog and 20 from Brownsville. Standard procedures for starch-gel electrophoresis were used (Harris and Hopkinson, 1976; Murphy et al., 1990). Locus nomenclature followed McAlpine et al. (1985) for mapped human genes. The 13 allozymes were analyzed using three buffer systems. We used tris-citrate, pH 6.7 for hexokinase, Enzyme Commission (E.C.) 2.7.1.1 (HK); isocitrate dehydrogenase, E.C. 1.1.1.42 (ICD-1); glucose phosphate isomerase, E.C. 5.3.1.9 (GPI); beta hemoglobin (BHb); lactate dehydrogenase, E.C. 1.1.1.27 (LDHA); malate dehydrogenase, E.C. 1.1.1.37 (MDH-1); and purine nucleoside phosphorylase E.C 3.4.2.1 (NP). Using tris-citrate, pH 8.0, we analyzed adenosine deaminase, E.C. 3.5.4.4 (ADA), glutamic-oxaloacetic transaminase, E.C. 2.6.1.1 (GOT-1); peptidases, E.C. 3.4.13 (PEPC: L-leucyl-L-alanine as substrate; PEPD: L-phenylalanyl-L-proline as substrate); and 6-phosphoglucomutase dehydrogenase, E.C. 1.1.1.44 (6-PGD). Poulik was used for superoxide dismutase, E.C. 1.15.1.1 (SOD-1). Numerous side-by-side comparisons of electromorphs were made to assure correct assessment of relative mobilities. Electromorphs were assumed to represent alleles and were assigned unique letters, with "A" designating the most common allele.

Allozymic results were summarized and analyzed statistically using BIOSYS-1 (Swofford and Selander, 1981). Hardy-Weinberg equilibrium was tested using exact significance probabilities. Chi-square contingency tests were used to test for homogeneity of allele frequencies among populations. Gene flow (Nm) was estimated using Wright's (1951) original formula. This method was chosen over the rare alleles method (Slatkin, 1985b) because of the problems associated with detecting and scoring rare alleles in electrophoresis. A phenogram was constructed using UPGMA (Sneath and Sokal, 1973) and a matrix of Rogers' (1972) genetic distances between pairs of populations. Mantel (1967) tests were used to test the association between geographic and genetic distances.

RESULTS

Direct method of measuring gene flow

Of the 219 rice rats tagged during the summer, only 11 (5%) were observed to have made inter-island movements. All movements were of rice rats leaving Crescent Island (the small island between the two larger islands) and arriving at the study sites on Parramore and Revel. Ten rice rats from Crescent were trapped 50 m away on Parramore and one Crescent rice rat was trapped 300 m away on Revel. Averaging the number of movements between each site over the total

TABLE 1. Allelic frequencies for the three variable loci[a] in one mainland and four island populations of *Oryzomys palustris* on the Virginia Barrier Islands.

		Site				
Locus	Allele	Crescent (28)	Revel (28)	Parramore (8)	Hog (25)	Brownsville (20)
ADA	A	0.268	0.130			0.300
	B	0.554	0.574	0.714	0.500	0.450
	C	0.179	0.296	0.286	0.500	0.250
6-PGD	A	0.667	0.618	0.333	0.500	0.867
	B	0.333	0.382	0.667	0.500	0.133
SOD-1	A	0.482	0.482	0.429	0.280	0.639
	B	0.518	0.518	0.571	0.720	0.361

[a]The following loci were monomorphic: GPI, GOT-1, Hb, HK, ICD-1, LDHA, MDH-1, NP, PEPC, PEPD.

number of site pairs (16 possible movement directions), the direct estimate of gene flow was 0.75 migrants per generation for the five sites.

Three of the dispersers were juveniles (two males, one female), three were subadults (all females) and five were adults (all males). All inter-island dispersers were trapped for the duration of the study only at the sites to which they had migrated. All of the subadults and adults appeared to be sexually active, but none of the females were noticeably pregnant during the summer.

Indirect method of measuring gene flow

Three polymorphic loci (ADA, 6-PGD, and SOD-1) were identified in the five populations (Table 1). Deviations from Hardy-Weinberg expectations were observed ($P < 0.001$) at a single locus (ADA) in three of the populations (Crescent, Revel and Brownsville). The F_{IT} and F_{IS} values (measures of deviation from Hardy-Weinberg proportions) were positive for all three of the loci, indicating an excess of homozygotes. Highly significant genic differentiation was observed among the sites at all three polymorphic loci: ADA ($X^2 = 33.82$, d.f. $=8$, $P < 0.001$), 6-PGD ($X^2 = 21.04$, d.f. $= 4$, $P < 0.001$), SOD-1 ($X^2 = 11.14$, d.f. $= 4$, $P < 0.025$), and overall heterogeneity was highly significant ($X^2 = 66.00$, d.f. $= 16$, $P < 0.001$).

The estimates of Nm (Table 2) were all greater than one, indicating that gene flow was sufficiently strong to prevent genetic drift from causing local genetic differentiation (Slatkin, 1987). To estimate the actual amount of the population immigration (m) it is necessary to make an estimate of the average effective population (N_e). There was not sufficient data to calculate N_e. However, because of a prior study (Forys, 1990) that documented the sex ratio for 15 rice rat

TABLE 2. The estimates of Nm and F_{ST} for three polymorphic loci from one mainland and four insular populations of *Oryzomys palustris*.

Locus	F_{ST} (mean)	Nm(estimated)
ADA	0.062	3.78
6-PGD	0.130	1.67
SOD-1	0.053	4.47

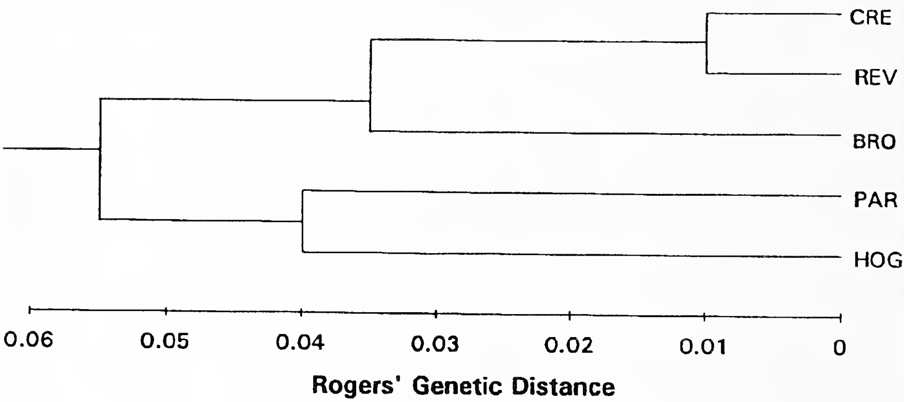

FIGURE 2. UPGMA phenogram depicting relationships among the five populations (located on: PAR = Parramore, CRE = Crescent, REV = Revel, HOG = Hog, and BRO = Brownsville) of *Oryzomys palustris* based on Rogers' genetic distance (1972).

populations to be near 1:1, the assumption was made that Ne = 2N (Lande and Barrowclough, 1987).

To calculate the average population size (N), the average density of the five sites (X = 8.78, SE = 2.83) (Forys and Dueser, 1993) was used. Extending this estimate over the area of the grids, the average population size (N) was 18.79 rats. The equation below was used to calculate the number of migrants per generation (m) using Wright's (1951) original formula with the substitution of Ne, where F_{ST} is the measure of the genetic differentiation of subpopulation.

$$m = \frac{F_{ST}}{2(N)}$$

Using this equation the estimate of m is 0.09, or 0.09 migrants per generation among the five sample sites.

Genetic distance

Rogers' (1972) genetic distance coefficients ranged from 0.014 for the Revel-Crescent comparison to 0.079 for the Parramore-Brownsville comparison. The UPGMA phenogram (Figure 2) indicated two major groupings: the adjacent islands of Crescent and Revel grouped with the mainland site (Brownsville), and the larger barrier islands of Hog and Parramore formed a separate group. The Mantel test indicated that genetic and geographic distance were not correlated for the five populations ($r = 0.064$, $P = 0.482$).

DISCUSSION

During the summer of 1989, movements of *O. palustris* across 50 m of water occurred several times (10) per generation (1 year), but dispersal across 300 m of water was recorded only once. No movement was observed between sites separated by more than 300 m. It is possible that more over-water movements may have occurred during the year, but the summer was deemed the most likely time of year for inter-island dispersal by small mammals due to the higher water temperature.

The direct estimate of gene flow (0.75) was over eight times the indirect estimate (0.09) for the same five sites. This could be due, in part, to experimental errors caused by sampling individuals for the indirect estimate of gene flow from only one part of each island. These subpopulations may not be representative of the entire island population, and the genetic composition of the subpopulations may have been affected not only by inter-island movements but by intra-island movements of individuals. However, this potential sampling bias does not completely explain the higher direct estimate. The higher direct estimate may indicate that, although individuals are successfully crossing the water barrier and surviving on islands to which they dispersed, they are not successfully breeding. This explanation is supported by the fact that the five sites were significantly different genetically despite the number of movements seen during the summer of 1989. Several studies of small mammal populations have documented the inability of immigrants to penetrate established groups (Festa-Bianchet and King, 1984; Schwartz and Armitage, 1981).

The discrepancy in the direct and indirect estimates obtained in this study may also reflect the differences in the time scales incorporated by these estimates. The barrier island complex is highly susceptible to storms (as evidenced by the storm in October 1991 that eliminated the water channel between Parramore and Crescent islands). Geologic evidence suggests that the larger barrier islands have migrated landward by both erosion on their seaward margins and accretion on their bayside (Dolan et al., 1979). It is possible that in the recent past, some of the islands included in this study were spaced farther apart and/or that some of the low-lying marshes between the islands (that may serve as stepping stones) have changed their configurations.

These changes in the configurations of the barrier islands and the effects of storms may also explain the fact that the Mantel test did not reveal a correlation between genetic and geographic distance. It is noteworthy that the greatest disparity in the geographic and genetic distances was between rice rat populations on Crescent and Parramore Islands. Despite being separated from Parramore by only 50 m of water, Crescent Island is more similar to Revel (300 m away) and the

mainland (> 7 km away) than it is to the population on Parramore. The Parramore population was most similar to that on Hog in terms of genetic distance. These genetic affinities may be the result of recolonization from different source populations following storms and island movements. For example, after the large Northeastern storm of 1988 when the southern tip of Parramore and Crescent were overwashed, Crescent may have been recolonized by individuals on Revel, while the site on Parramore was recolonized by individuals from other marshes on Parramore. More data on the geologic history of the barrier islands and a more comprehensive assessment of genetic variation among populations are needed before a complete colonization scenario can be proposed for the *O. palustris* populations on the Virginia Barrier Islands.

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Characterization of Corn Earworm Larval Growth on Soybean Terminals [1]

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ABSTRACT

A comparison of weights of larvae, raised for 14 days on 30 soybean cultivars (five each from six maturity groups), identified Gnome-85, Essex, and Padre to be susceptible and Newton, Walters, and Colquitt to be resistant to foliar feeding by corn earworm (*Helicoverpa zea* Boddie). In general, the larvae grew better on cultivars of northern maturity groups (II, III, and IV) as compared to cultivars of southern maturity groups (V, VI, and VII). The larvae raised on susceptible cultivars had higher lipid contents (fresh weight basis) as compared to those raised on resistant cultivars. Differences existed for contents of saturated and unsaturated fatty acids in larvae raised on susceptible or resistant cultivars. These results indicate that chemical composition of terminals might be involved in soybean resistance to corn earworm and that it might be possible to develop resistant soybean cultivars based on comparisons of chemical constituents in the terminals.

INTRODUCTION

Corn earworm (*Helicoverpa zea* Boddie) is a devastating pest of row crops causing major damage on corn, cotton, peanut, and soybean. Kogan (1980) found that corn earworm had the greatest economic impact on crop production in the United States of America. It causes primary damage to soybean pods before seed enlargement begins which affects yield and seed quality (Biever et al. 1983). Although, most serious damage to soybean, *Glycine max* (L.) Merr., occurs from southern Virginia to Alabama (Stinner et al. 1980), other southern production regions may also suffer damage (Turnipseed and Kogan, 1987).

Concerns for environmental quality and cost of insect control have resulted in concerted efforts aiming to develop host plant resistance in field crops, including soybean. Rufener et al. (1987) developed a larval antibiosis screening technique to screen soybean for resistance to mexican bean beetles (*Epilachna varivestis* Mulstant). This laboratory technique is based on larval maturity and mortality after 10 days of feeding on excised leaflets of various soybean lines. High mortality or slow larval development was used to indicate high level of antibiosis resistance. A comparison of larval weights after 14 days feeding on excised leaves in the

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1 Contribution of Virginia State University, Agricultural Research Station Journal Article No. 190. The use of any trade names or vendors does not imply approval to the exclusion of other products or vendors that also may be suitable.

2 Send correspondence to: Harbans L. Bhardwaj, Agricultural Research Station, Virginia State University, Box 9152,Petersburg, VA 23806.

laboratory was successfully used by Bhardwaj et al. (1987) to characterize bollworm resistance in cotton lines. Larval weights after 5-8 days of feeding on resistant and susceptible cultivars were demonstrated to be an acceptable measurement of soybean resistance to various insect pests by Beach and Todd (1988). Javaid et al. (1991) and Joshi et al. (1991) used weights of corn earworm larvae when raised on terminals of soybean lines to successfully identify corn earworm-resistant lines.

Three plant introductions (PI-229358, PI-171451, and PI-227687) have been identified as sources of resistance to foliar feeding insects in soybean (Van Duyn et al. 1971; Clark et al. 1972). Even though progress has been made to genetically enhance corn earworm resistance in soybean, progress has been slow in developing insect-resistant cultivars with acceptable yields (Javaid et al. 1991).

Our objective was to screen recently released, high yielding soybean cultivars for resistance to corn earworm foliar feeding. The intent was to identify resistance in these agronomically desirable cultivars rather than in unadapted genotypes with unacceptable yield potential that would have to be improved. Variation in larval weights was used to characterize soybean cultivars for their ability to support corn earworm larval growth. The cultivars on which the larval growth was minimal were classified as resistant whereas those on which larvae attained significantly more weight were classified as susceptible. The contents of various fatty acids in larvae raised on resistant and susceptible cultivars were also compared.

MATERIALS AND METHODS

During 1992, 285 soybean cultivars representing 12 maturity groups (OO, O, I, II, III, IV, V, VI, VII, VIII, IX, and X) were planted on May 14, 1992, at Randolph Farm of Virginia State University for seed multiplication and observations. Each cultivar was planted in a single row. The distance between rows was 75 cm, and the plants were spaced approximately 5 cm apart within rows. Recommended cultural practices for soybean production in Virginia (Reese, 1992) were followed. Thirty soybean cultivars, five each from six maturity groups (II, III, IV, V, VI, and VII), were selected for inclusion in the present study based on availability of sufficient foliage, most recent release date, and availability of resources. These thirty cultivars were registered from 1988 to 1992 except for Essex which was registered in 1973.

Terminals (approximately upper 15cm of the plants) from 56 to 63 days old soybean plants were harvested from the field and brought to the laboratory. Eight to ten terminals were placed on a 12.5cm diameter Whatman filter in a disposable petri dish. Approximately 5 newly hatched corn earworm larvae were placed in each petri dish. The larvae were reared from eggs obtained from the Insect Rearing Laboratory, USDA-ARS, Stoneville, MS 38776. The filter papers were kept moist with tap water during the duration of the experiment to keep soybean terminals from drying. Six petri dishes were used for each cultivar. The petri dishes were arranged in the laboratory in a randomized complete block design with six replications. On the eleventh day of these experiments, old terminals were replaced with fresh terminals, mainly to clean the larvae of feces, etc. and to facilitate larval handling. These larvae were weighed on an electronic scale on the fourteenth day. If significant differences for larval weight existed among cultivars within a maturity group, the cultivar on which the highest larval weight was observed was classified

as susceptible whereas the cultivar on which the lowest larval weight was observed was classified as resistant to corn earworm feeding. The terms susceptible and resistant are derived from comparative growth of corn earworm larvae on terminals of respective soybean cultivars in the laboratory and may not relate to actual losses caused by corn earworm under field conditions.

Upon recording of larval weights on the fourteenth day, all larvae from six petri dishes of a cultivar were composited to form one sample. These samples were immediately frozen. The lipids were extracted from frozen corn earworm larvae by hexane-isopropanol (3:2 v/v) according to the method of St. John and Bell (1989). The fatty acid methyl esters (FAME) were prepared from extracted lipids as described by Mohamed and Rangappa (1992). The FAME were analyzed on Supelcowax 10 capillary column (30m x 0.25 mm i.d. and 0.235 m film thickness) in a Hewlett-Packard model 5890 gas chromatograph equipped with a flame ionization detector (FID). Helium was used as a carrier gas at a flow rate of 1.85 ml/minute with split ratio of 1:100. The oven temperature was isothermal at 270°C with injector and deflector temperature set at 250 and 260°C, respectively. Identification of FAME was based on comparison of retention time of unknown peaks to fatty acid methyl ester standards. Quantification of various fatty acids was done by the aid of heptadecanoic acid (17:0) as an internal standard. At least three injections were made for each sample. Individual fatty acids were expressed as a relative weight percentage of total fatty acids. Comparisons were made for fatty acid profiles between larvae raised on resistant and those raised on susceptible cultivars as identified by comparison of larval weights.

All data were analyzed using Analysis of Variance and Duncan's Multiple Range Test at a 5% level of significance (SAS, 1989).

RESULTS AND DISCUSSION

Significant differences in larval weights were observed only when corn earworm larvae were raised on cultivars of maturity groups II, V, and VII (Table 1). Based on these comparisons, Gnome 85 (MG II), Essex (MG V), and Padre (MG VII) were classified as susceptible and Newton (MG II), Walters (MG V), and Colquitt (MG VII) were classified as resistant to corn earworm feeding.

A comparison of the lipid content in larval bodies (Table 2) indicated that corn earworm larvae fed on susceptible cultivars accumulated more lipid in their bodies as compared to those fed on resistant cultivars. In maturity group V, the differences were significant at the 5% level. The overall mean lipid content in corn earworm larvae fed on susceptible cultivars was approximately three times greater than for larvae fed on resistant cultivars (97 vs. 284 μg/g). We did not analyze the soybean foliage but it seems that chemical composition of terminals of susceptible cultivars might be different from that in resistant cultivars since the diet of corn earworm larvae in this study consisted only of soybean terminals.

Further evaluations revealed differences for fatty acids among corn earworm larvae fed on resistant and susceptible cultivars. The fat in the bodies of larvae fed on susceptible cultivars contained long chain fatty acid ($C_{22:0}$) whereas the fat in the bodies of larvae fed on resistant cultivars lacked this fatty acid (Table 2). The larvae fed on susceptible cultivars also had lower contents of $C_{18:0}$ fatty acid as compared to those fed on resistant cultivars. However, this situation was reversed

TABLE 1. Weights of 14 day old corn earworm larvae fed on soybean terminals.

Maturity Group	Cultivar	Larval Weight(mg)		Rating
II	Gnome 85	225.5	a*	Susceptible**
II	Amcor 89	202.9	ab	-
II	Chapman	196.0	ab	-
II	Hoyt	145.2	bc	-
II	Newton	123.3	c	Resistant
III	Kunitz	135.6	a	-
III	Dunbar	124.1	a	-
III	Hayes	117.9	a	-
III	Sprite 87	106.6	a	-
III	Hobbit	102.2	a	-
IV	Pixie	174.7	a	-
IV	Ripley	168.2	a	-
IV	Spry	112.4	a	-
IV	Hamilton	110.5	a	-
IV	Delsoy 4900	85.8	a	-
V	Essex	192.7	a	Susceptible
V	Hartwig	157.0	b	-
V	TN5-85	117.3	c	-
V	Hutcheson	91.9	cd	-
V	Walters	72.6	d	Resistant
VI	Asgrow 6785	89.8	a	-
VI	Twiggs	79.1	a	-
VI	Sharkey	70.4	a	-
VI	Bryan	65.3	a	-
VI	Lloyd	45.7	a	-
VII	Padre	137.2	a	Susceptible
VII	Stonewall	112.5	ab	-
VII	Thomas	99.9	ab	-
VII	Hagood	63.9	bc	-
VII	Colquitt	42.2	c	Resistant

*Means followed by similar letters within maturity groups are not different according to Duncan's Multiple Range Test ($P = 0.05$).

** Rating of host plant reaction to corn earworm feeding. If significant differences existed among cultivars within a maturity group, the cultivars with extreme larval weights were classified as resistant or susceptible.

TABLE 2. Comparison of lipid profiles of corn earworm larvae fed on resistant and susceptible soybean cultivars.

Fatty Acid(%)	Mat. Group = II		Mat. Group = V		Mat. Group = VII		Overall	
	Res[a]	Sus	Res	Sus	Res	Sus	Res	Sus
16:0	18.4[b]	16.1	16.8	12.1*	20.3	24.5	18.5	17.6
16:1	3.1	1.4	3.0	1.1**	2.5	5.8	2.9	2.8
18:0	20.1	14.9**	17.3	17.3	16.0	12.6*	17.8	14.9*
18:1	19.9	17.2	20.4	16.5**	14.4	17.0	18.3	16.9
18:2	14.5	16.5	17.4	11.7**	11.5	6.9*	14.4	11.7
18:3	17.6	19.5	21.8	30.5**	28.1	27.2	22.5	25.7
20:0	0.8	1.0	1.8	1.4	0.8	0.8	1.1	1.1
$\mu 1$[c]	5.5	3.8	1.6	3.8	6.5	3.9	4.5	3.9
22:0	0.0	0.4	0.0	1.2*	0.0	0.0	0.0	0.5*
$\mu 2$[d]	0.0	9.3**	0.0	4.4	0.0	1.3	0.0	5.0*
Total Lipids (μg/g)	100.6	272.4	88.6	288.1*	102.3	292.1	97.1	284.2**

[a]Corn earworm larvae raised on resistant (Res) or susceptible (Sus) soybean cultivars.
[b]Percent content of fatty acids in total lipids based on fresh body weight.
[c]Unsaturated C_{20} fatty acid. The number of double bonds is unknown.
[d]Unsaturated C_{22} fatty acid. The number of double bonds is unknown.
*,**The mean fatty acid contents differed significantly in corn earworm larvae fed on resistant or susceptible soybean cultivars within maturity groups (P = 0.05 and0 .01, respectively).

with respect to linolenic acid ($C_{18:3}$), where the larvae fed on susceptible cultivars had higher content. Since the corn earworm larvae were raised under controlled conditions from a common genetic stock, lack of genetic differences among larvae can be safely assumed. Hence, the differences in fatty acids among corn earworm larvae fed on susceptible and resistant cultivars must be associated with differences in their diet i.e. soybean terminals. These studies indicate a need for chemical analysis of soybean terminals in order to relate variation in chemical composition to corn earworm larval growth.

The essential fatty acids, which include linoleic acid and linolenic acid, serve several physiological functions in vertebrates. The differences in lipid and fatty acid contents between corn earworm larvae raised on resistant and those raised on susceptible soybean cultivars indicate that a strategy to block lipid accumulation in corn earworm might be a potential means of corn earworm resistance in soybean.

The larvae of many species are important food items in many parts of the world (DeFoliart, 1991). The analyses of the nutritional value of 22 species of caterpillars revealed that kcal/100 grams dry weight averaged 457, ranging from 397 to 543, and crude protein content averaged 63.5%, ranging from 45.6% to 79.6% (Malaisse and Parent, 1980). Most species were also observed to be excellent sources of iron. The considerable proportion of 18:0, 18:1, 18:2, and 18:3 fatty acids in bodies of corn earworm larvae indicates the possibility that a soybean cultivar could be identified to raise corn earworm larvae to provide a source of these fatty acids for human or animal nutrition.

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Mid-Summer Abundance of Resident Sub-Adult Marsh Nekton at the Virginia Coast Reserve

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ABSTRACT

We compared mid-summer abundance of resident sub-adult finfish (*Fundulus* spp.) and daggerblade grass shrimp (*Palaemonetes pugio*) at mainland and back-barrier salt marshes. Pit traps were used to collect marsh surface nekton from June 10 - August 15, 1991 at two marshes located within the Virginia Coast Reserve Long-Term Ecological Research Site. Significantly greater abundance of fishes (but not grass shrimp) was observed at the mainland marsh. Bi-weekly periodicity in shrimp and finfish abundance was observed at the mainland site only. Site-specific and temporal patterns of sub-adult nekton abundance were determined primarily by differences in elevation and hydroperiod of each marsh. Spotfin killifish (*Fundulus luciae*), previously considered rare on Virginia's Eastern Shore, were frequently collected at the mainland marsh.

Key Words: mummichogs, *Fundulus heteroclitus*, grass shrimp, *Palaemonetes pugio*, salt marshes, Virginia Coast Reserve

INTRODUCTION

In summer, 1991, we conducted a 10 week pilot study in order to evaluate the effectiveness of pit traps (Kneib, 1978; 1984; Talbot and Able, 1984) as a technique for estimating relative abundance of marsh-surface nekton (primarily juvenile cyprinodont fishes and decapods) on the surface of coastal salt marshes within the Virginia Coast Reserve barrier island-lagoon complex. Previous studies of marsh dependent/resident nekton populations at the VCR are few, and mostly limited to seine and trawl surveys scattered widely in space and time (Richards and Castagna, 1970; Norcross and Hata, 1990).

The importance of the vegetated marsh surface as habitat for larval and juvenile marsh-resident finfish and invertebrates has been emphasized (Boesch and Turner, 1984; Zimmerman and Minello, 1984; Kneib, 1984; 1986; 1987a; 1987b). Larval and juvenile fishes and decapods may forage effectively on the flooded marsh surface, yet avoid predation by seeking temporary refuge in shallow intertidal pools and rivulets at low tide. (Kneib, 1984; 1986; 1987a). Few previous studies have compared use of the marsh surface by resident sub-adult nekton at disparate marsh sites within a single dynamic system such as the Virginia Coast Reserve (VCR).

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STUDY AREA

This study was conducted in marshes of the Virginia Coast Reserve Long-Term-Ecological Research Site (VCR-LTER). Within the VCR complex, salt marsh development occurs primarily as fringing coastal marshes associated with the mainland Delmarva Peninsula and as back-barrier marshes located on the landward side of barrier islands. Additional isolated marsh islands occur in mid-lagoon areas, however, they represent a relatively minor percentage of total marsh area in this system. Mainland marshes are accreting due to relative sea-level rise (subsidence) whereas back-barrier marshes are undergoing erosion (Hayden et al., 1991). A mainland salt marsh located in Northampton County, Virginia (USGS Nassawadox quadrangle) and a back-barrier marsh located on the northern end of Hog Island (USGS Quinby Inlet Quadrangle) were chosen for comparison (Figure 1). The mainland marsh was located along a second order tributary of Phillips Creek (hereafter referred to as Phillips Creek Marsh). Emergent vegetation at this site consisted primarily of medium to short form *Spartina alterniflora* with *Salicornia virginica* and *Distichlis spicatum* occurring throughout an extensive upper intertidal zone. This site was flooded entirely only on spring and storm tides and average depth of flooding in the lower intertidal zone was $\approx$10 - 15 cm. The topographic profile of this marsh was relatively level, with a distinct berm (levee) adjacent to the creekbank. Flooding water (and presumably marsh-dependent nekton) accessed the marsh via several intertidal rivulets located along the creekbank, dissecting the berm.

The back-barrier marsh chosen for this study was a marsh island located at the northwest end of Hog Island. A tidal creek (Cattleshed Creek) flowed around the entire marsh, and a berm was present around the marsh perimeter. The tall form of *Spartina alterniflora* was the predominant vegetation present. Flooding water and nekton reached the marsh surface via a tributary creek entering at the western boundary of the marsh. The marsh was regularly flooded to depths of > 0.5 m.

METHODS

We installed 10 clay pots (18 cm diameter, 18 cm depth) at randomly selected locations within the low marsh at each site. These traps emulated the shallow intertidal microhabitats available to sub-adult nekton at low tide (Kneib, 1984) and collected resident fishes and decapods remaining on the marsh as the tide receded. Traps were sampled weekly for a total of 10 visits to each site from June 10 through August 15, 1991. We attempted to sample on mornings of consecutive days during each week, however, some samples from both sites were collected during mid-day, as dictated by tidal conditions. Larval and juvenile fishes and grass shrimp were removed from traps by repeated circular sweeps with a small dip net. Initially, traps were left uncovered between sampling intervals. However, within several days, fiddler crab (*Uca pugnax*) carcasses filled the traps. Installation of nylon mesh covers (12 mm diam.) during the second week of the study significantly reduced the accumulation of crabs in traps and did not appear to inhibit use of the traps by sub-adult finfish and decapods. On each sampling date, we measured surface water temperature, salinity and dissolved oxygen content within traps using a stem thermometer, a Reichert-Jung temperature-compensated refractometer, and a YSI Model 57 Oxygen Meter. In addition, average stem density of emergent

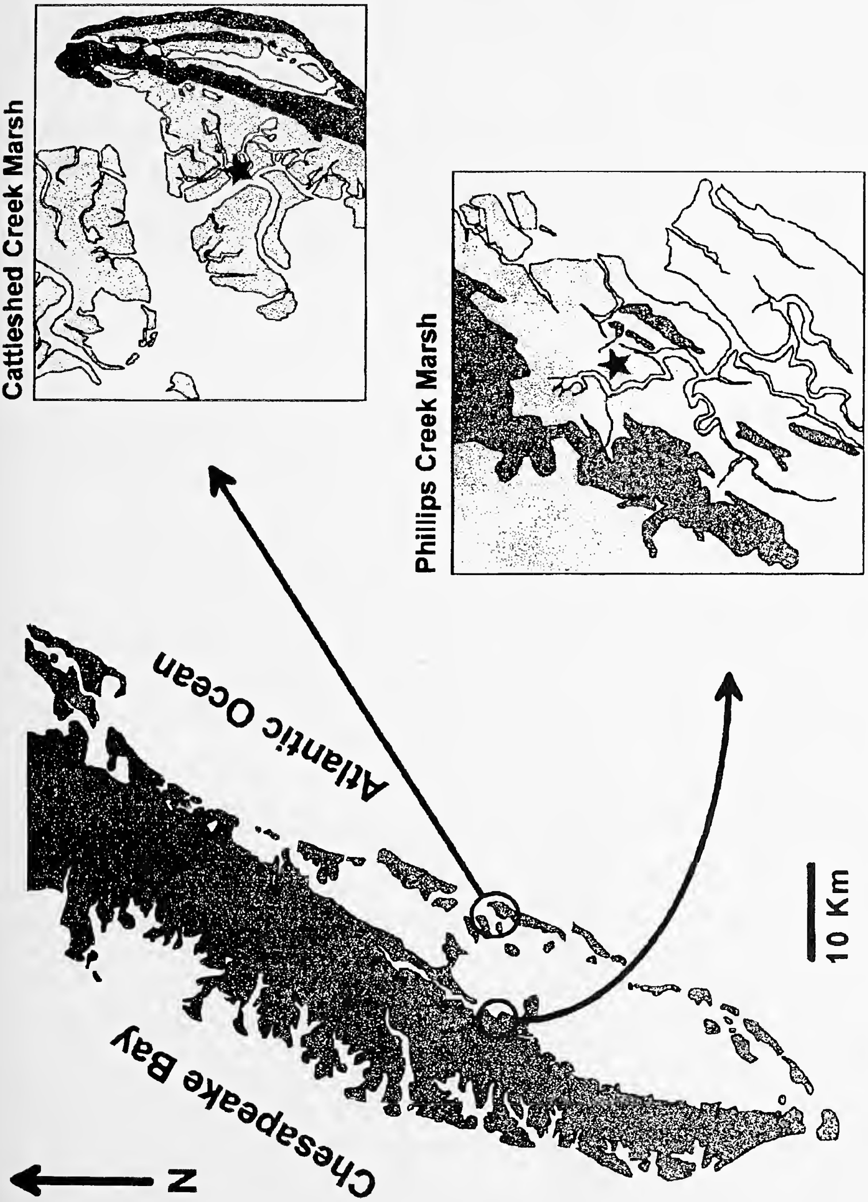

FIGURE 1. Map of the lower Delmarva peninsula and marsh study areas.

macrophytes was determined once in late July by counting individual plant stems in triplicate 0.0625 m^2 plots located randomly at each site. In the laboratory, larval and juvenile fishes and shrimp were identified to species, counted and measured (TL, in mm). Total (unpreserved) biomass of organisms (mg wet wt.) per trap was determined. All specimens were fixed in 10% buffered formalin. Following fixation, all specimens were preserved in 70% ethanol and archived at the University of Virginia's Long-Term Ecological Research Laboratory in Oyster, Virginia.

Statistical Analyses

We tested for differences in abundance of fishes and grass shrimp between each site using a repeated measures analysis of variance with SITE as the between subjects factor and SAMPLING DATE as the within subjects factor. Abundance data were normalized using a log (y + 1) transformation (Sokal and Rohlf, 1981). Statistical analyses were performed using SuperANOVA software for the Macintosh PC (Abacus Concepts, 1989).

RESULTS

Site Conditions

Artificial microhabitats at the mainland marsh were characterized by higher average salinity and temperature relative to back-barrier marsh microhabitats (Table 1). Mean dissolved oxygen content within traps was also higher at the mainland marsh. Hypersalinity in surface waters (66 ppt) was measured on July 16 at the mainland marsh. Maximum air temperature on this day was 30.0 ^{o}C . Average monthly precipitation (Painter, Virginia Climate Station) was 75.1 mm, a -29.5 mm departure from the monthly normal (1951-1980). The average daily temperature at this station was 27.0 ^{o}C., a 3.8^{o} departure above the 1951-1980 station normal for July. (NOAA, 1991). Mean stem density of emergent macrophytes (primarily *Spartina alterniflora*) was nearly twice as high at the mainland marsh (mean = 502.4 ±41.1 m-2 vs. 249.9 ±13.0 m^{-2}).

Abundance and Composition

We collected a total of 546 fishes and 1182 decapods during the 10 week study interval. Mummichogs (*Fundulus heteroclitus*) represented 94% of all fishes collected. Spotfin killifish (*Fundulus luciae*) comprised the remaining 6%. The daggerblade grass shrimp *Palaemonetes pugio* was the sole decapod species captured (exclusive of fiddler crabs *Uca pugnax* which were not considered nekton). Significantly more fishes were collected at the mainland marsh site ($p = 0.0009$). Grass shrimp abundance did not differ significantly between marshes (Table 2). There were significant SITE x SAMPLING DATE interactions for both taxa ($p = 0.0001$) *Fundulus* spp. occurred at both sites on all sampling dates. Grass shrimp were not collected until week 5 (early July). The most striking difference in abundance between the two sites is the occurance of a distinct bi-weekly periodicity in shrimp abundance at the mainland marsh (Figure 2). This trend is absent at the island marsh. A similar, though less extreme, pattern is observed for fishes at the mainland marsh.

Larvae and juveniles comprised 95% of total fishes collected. Larvae and juveniles comprised 68% of total grass shrimp collected. Greater proportions of

TABLE 1. Ranges and means (± 1 SE) of marsh surface water salinity, temperature and dissolved oxygen content at Phillips Creek Marsh and Cattleshed Creek Marsh, June 10 - August 15, 1991.

Site	Range	Mean (± 1 SE)
Phillips Creek (mainland)		
Salinity (ppt)	28 - 66	43.3 ± 2.3
Temperature (°C)	24 - 37	31.0 ± 1.1
Dissolved Oxygen (mg/L)	0.4 - 15.8	5.3 ± 1.0
Cattleshed Creek (back-barrier)		
Salinity (ppt)	30 - 40	24.9 ± 0.
Temperature (°C)	24 - 34	27.8 ± 0.9
Dissolved Oxygen (mg/L)	0.4 - 16.2	3.4 ± 1.1

TABLE 2. Repeated Measures ANOVA comparing *Fundulus* spp. and *P. pugio* abundance between mainland and back-barrier marsh sites.

Source	SS	df	MS	F	p
Fundulus spp.					
Site	2.843	1	2.843	15.945	0.0009
Week	4.802	9	0.534	8.262	0.0001
Site x Week	2.763	9	0.307	4.754	0.0001
P. pugio					
Site	0.032	1	0.032	0.193	0.6653
Week	43.327	9	4.814	91.411	0.0001
Site x Week	9.106	9	1.012	19.211	0.0001

total catch were represented by sub-adult fishes and shrimps at the mainland marsh (Table 3). A slightly greater range of sizes was also noted at the mainland marsh for both fishes and shrimps. Mean total length (mm) was greater for all three species at the back-barrier marsh.

DISCUSSION

Our results are consistent with previous studies of habitat use by sub-adult nekton in Atlantic Coast salt marshes. We observed an early summer abundance peak of cyprinodont (primarily *Fundulus heteroclitus*) larvae and juveniles in mainland marshes. A second peak, representing a later cohort, occurred in late summer. We did not sample into autumn, however, more recent data from mainland marsh sites indicates that an additional cohort is produced in September - October. These data are similar to patterns of abundance reported by Kneib (1986)

for *F. heteroclitus* at Sapelo Island, Georgia. He documented three distinct abundance peaks corresponding to full moon phases of the lunar cycle. Abundance data for *Palaemonetes pugio* also correspond to observations of this species in other coastal systems. We observed a distinct bi-weekly periodicity in abundance of *P. pugio* from early July, when young individuals recruited to the marsh, to mid-August. Kneib (1987b) reported a similar bi-weekly periodicity in abundance pulses of sub-adult *P. pugio* in Sapelo Island marshes. Curiously, bi-weekly periodicities were absent in back-barrier marsh populations of fishes and shrimp in our study. The major difference between the two sites in our study was hydroperiod. Our observations indicate that the back-barrier marsh flooded regularly and to a significant depth ($\approx$ 50 cm). In contrast, the mainland marsh was generally flooded only on spring tides and average flooding depth was relatively low ($\approx$ 10-15 cm). This marsh was subsequently instrumented with a Qualimetrics Richards-Type water level recorder. Recent data (March 1993 - present) confirm our earlier observations on flooding frequency/depth at this location.

Kneib (1993) reported that growth of *F. heteroclitus* larvae was positively associated with flooding duration, and hypothesized that tidal flooding controlled the renewal rate of prey resources available to larvae. Our size/age composition data support this, with larger individuals collected from the back-barrier marsh (Table 3), however, our sampling techniques were selective for larvae and juveniles, and likely excluded late juveniles and adults at both sites.

We sampled a single location (lower intertidal zone) at each marsh in our comparison. In an earlier study (Kneib, 1984), significant variation in abundance of larval and juvenile cyprinodonts (*Fundulus heteroclitus* and *Fundulus luciae*) was reported across an intertidal transect at a Sapelo Island, Georgia salt marsh, with greatest abundance occurring in the upper intertidal zone. Larvae and early juveniles were most abundant at higher elevations, whereas larger juveniles and adults dominated collections from the lower intertidal.

It has been documented that spawning activity (as indicated by egg counts and gonadosomatic indices) in *Fundulus heteroclitus* peaks in concert with spring tides in mid-Atlantic marshes (Taylor et al., 1979). Kneib (1987b) suggested that grass shrimp temporal abundance patterns may be similarly influenced by lunar cycles, either via synchrony of reproductive activity or as a function of increased access to the marsh surface due to higher spring tides. The greater availability of high marsh at the mainland site may explain the higher abundance of resident finfish at that location. The back-barrier site was almost entirely low marsh, except for a restricted area of short-form *Spartina alterniflora* located upon the berm. If the high marsh environment is preferentially utilized as a spawning site and nursery area by *Fundulus heteroclitus* and *Fundulus luciae* (Byrne, 1978; Kneib, 1984; Talbot and Able, 1984) recruitment of larval and juvenile cyprinodonts would have been enhanced at our mainland site. Grass shrimp do not utilize the intertidal marsh surface as a spawning site. However, post-larval grass shrimp (6 - 8 mm) recruit from sub-tidal creeks to the intertidal marsh surface during mid- to late summer (Kneib, 1987). At this time, grass shrimp are the numerically dominant organism present on the lower intertidal marsh surface.

Our observations are not intended to suggest that all mainland marshes support greater abundance of marsh-resident nekton relative to all back-barrier locations

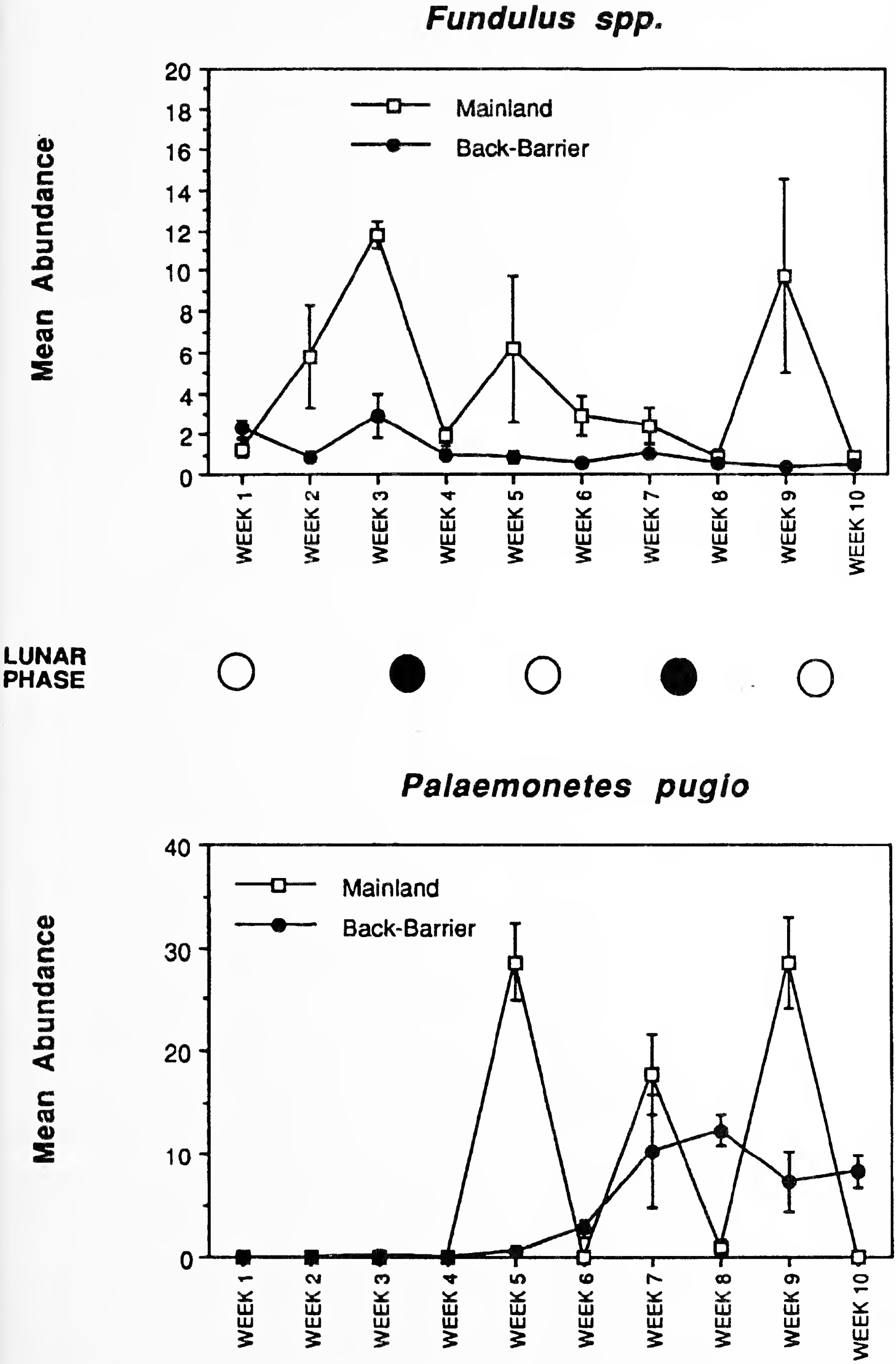

Figure 2. Mean weekly abundance of fishes (*Fundulus* spp.) and decapods (*Palaemonetes pugio*) on the surface of mainland and back-barrier marsh study sites; June 10 - August 15, 1991.

TABLE 3. Total length ranges and means and age class composition of fishes and grass shrimp at Phillips Creek Marsh and Cattleshed Creek Marsh, June - August, 1991.

Site	n	TL range (mm)	mean TL (mm)	% sub-adult	% adult
Phillips Creek (mainland)					
F. heteroclitus	404	6 - 35	11.9	96	4
F. luciae	29	9 - 24	14.4	97	3
P. pugio	763	6 - 25	11.3	76	24
Cattleshed Creek (back-barrier)					
F. heteroclitus	110	6 - 34	16.8	92	8
F. luciae	3	22 - 27	24.7	0	100
P. pugio	418	8 - 20	13.2	64	36

at the VCR. Many back-barrier marshes at the VCR are contiguous with terrestrial island environments and contain substantial high marsh. However, marsh islands such as Cattleshed Creek Marsh are common at back-barrier locations. Our intention was to illustrate variation in marsh types within the VCR and compare patterns of habitat utilization by resident sub-adult nekton between disparate marshes.

We collected 29 sub-adult and adult spotfin killifish (*Fundulus luciae*) at the mainland marsh site. Three adults were collected at the back-barrier marsh. Richards and Bailey (1967) concluded that this species is either rare or occupies a limited niche on the seaside of Virginia's Eastern Shore. Byrne (1978) reported on the life history of this species from the York River drainage, Virginia and suggested that populations of this species may have been previously overlooked in Virginia. Similarly, Able et al., (1983) and Shields and Hayes (1983) have reported spotfin killifish to be locally abundant in New Jersey and North Carolina high marshes, respectively. We have collected this species from high marsh shallows, ponds and ditches at the VCR-LTER on numerous occasions in 1991 - 1993 and concur with the previously mentioned studies that *F. luciae* is underepresented in conventional seine and trawl surveys of coastal marshes due to the dependence of this species on upper intertidal marsh habitats.

CONCLUSIONS

Resident sub-adult finfish (*Fundulus* spp.) were more abundant at a mainland salt marsh relative to a back-barrier marsh. Abundance of daggerblade grass shrimp (*Palaemonetes pugio*) did not significantly differ between marshes. Between-site differences in elevation and hydroperiod and the relative availability of high marsh habitat are potential factors influencing the observed patterns of abundance.

Spotfin killifish were frequently encountered in this study and are apparently not uncommon in high marsh habitats at the VCR-LTER. As suggested by previous investigators, the purported rarity of *Fundulus luciae* in mid-Atlantic salt marshes

is due to under-representation by conventional sampling techniques combined with specific habitat requirements.

ACKNOWLEDGEMENTS

This study was supported by an award from the William H. Bannon Foundation to DJY and an NSF-REU fellowship (NSF Grant No. BSR-8702333-09) to AM. Additional financial support was provided by a Program Development Grant from the Virginia Sea Grant College Program to DES (grant No. NA90AA-D-SG045). We thank K. DeWulf and J. Kastler for field assistance. Figure 1 was prepared by M. Santos. Comments by two anonymous reviewers substantially improved the quality of the original manuscript. This is a contribution of the Virginia Coast Reserve Long-Term Ecological Research Program (NSF Grant No. BSR-8702333).

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JEFFRESS RESEARCH GRANT AWARDS

The Allocations Committee of the Thomas F. and Kate Miller Jeffress Memorial Trust has announced the award of Jeffress Research Grants to the institutions listed below to support the research of the investigator whose name is given. The Jeffress Trust, established in 1981 under the will of Robert M. Jeffress, a business executive and philanthropist of Richmond, supports research in chemical, medical and other natural sciences through grants to non-profit research and educational institutions in the Commonwealth of Virginia. The Jeffress Research Grants being announced here have been awarded in 1993.

The Jeffress Memorial Trust is administered by NationsBank of Virginia, N. A. Additional information about the program of the Trust may be obtained by writing to: Advisor, Thomas F. and Kate Miller Jeffress Memorial Trust, NationsBank, Trust Division, P. O. Box 26903, Richmond, VA 23261.

Samuel A. Abrash, University of Richmond, Photochemistry and Dynamics of Complexes of Hydrogen Sulfide with Acetylene and Ethylene in Inert Gas Matrices. $22,325 (one year).

Suzanne E. Barbour, Virginia Commonwealth University, Preparation and Characterization of Phospholipase A_2-Null Cells. $26,500 (one year).

Stephen J. Beebe, Eastern Virginia Medical School, Molecular Genetic Analysis of Cell Signal Transduction. $15,000 (one year renewal).

Timothy J. Bos, Eastern Virginia Medical School, Translational control of c-*jun*. $16,050 (one year).

Amy H. Bouton, University of Virginia, Molecular Cloning and Characterization of the $pp6V^{src}$-Associated Protein p130. $20,555 (one year renewal).

Karen J. Brewer, Virginia Polytechnic Institute and State University, Reduction Coupling of Carbon Dioxide Using Novel Bimetallic Catalysts. $16,662 (one year).

Daniel J. Burke, University of Virginia, Identifying Novel Factors That Regulate Spindle Function in the Yeast *Saccharomyces cerevisiae*. $18,550 (one year).

Jiande Chen, University of Virginia, Noninvasive Measurement of Migrating Motility Complex of the Human Small Intestine Using Surface Electrodes. $19,500 (one year renewal).

Alan T. Dorsey, University of Virginia, Theoretical Studies of Surface Conductivity. $19,676 (one year).

M. Samy El-Shall, Virginia Commonwealth University, Gas Phase Polymerization Catalyzed by Metal Cations. $26,780 (one year).

M. G. Finn, University of Virginia, Asymmetric Synthesis of Allenes with Titanium-Substituted Ylides. $19,650 (one year).

Anthony Frankfurter, University of Virginia, Antisense Peptides as Probes for Characterizing Microtubule Protein. $22,515 (one year).

Frederico Gonzalez-Fernandez, University of Virginia, Molecular Analysis of Interphotoreceptor Retinoid-Binding Protein. $29,523 (one year renewal).

Daniel J. Haisenleder, University of Virginia, Intracellular Regulation of Prolactin Gene Expression. $17,834 (one year).

Shelley Halpain, University of Virginia, Regulation of Dendritic Microtubules in Neurons. $16,375 (one year).

Ian Harrison, University of Virginia, Surface Dynamics of Single Molecules. $46,300 (one year).

Steven L. Herr, Virginia Commonwealth University, Bolometric Studies of the Optical Properties of Thin Film High Temperature Superconductors. $14,350 (one year renewal).

Julia W. P. Hsu, University of Virginia, Spatially Resolved Optical and Transport Properties of Compound Semiconductor Thin Films and Devices. $24,000 (one year).

Laura C. Huang, University of Virginia, *in vivo* Study of Anabolic Effects of Insulin Mediator. $20,795 (one year renewal).

Colleen Jackson-Cook, Virginia Commonwealth University, Genetic Factors in Human Sperm Aneuploidy. $28,002 (one year).

Xi Jiang, Eastern Virginia Medical School, Cultivation of Norwalk Virus in Cell Culture. $17,500 (one year).

Steve A. Kay, University of Virginia, Novel Circadian Phenotypes in Higher Plants. $32,000 (one year renewal).

Robert H. Kretsinger, University of Virginia, Determination of the Crystal Structure of Anthranilate Synthase. $12,000 (one year).

Mark Lee, University of Virginia, Proximity Effect at the Superconductor - Normal Metal Interface with the Perovskite High-T^C Superconductors. $21,000 (one year).

Barbara J. Mann, University of Virginia, Analysis of the Genes Encoding the Galactose Lectin of *Entamoeba histolytica*. $25,231 (one year renewal).

Francine Marciano-Cabral, Virginia Commonwealth University, The Chemotactic Response of *Naegleria fowleri* Amoeba. $13,000 (one year).

Laura K. Moen, Old Dominion University, Cloning and Expression of HTLV-1 Reverse Transcriptase. $15,000 (one year).

Mitzi Nagarkatti, Virginia Polytechnic Institute and State University, Role of adhesion molecules in experimental immunology. $14,650 (one year).

Mark D. Okusa, University of Virginia, Renal Alpha$_2$- Adrenergic Receptor Subtypes: Molecular Localization and Physiological Significance in Hypertension. $16,500 (One year renewal).

K. Kevin Pfister, University of Virginia, The Mechanism of Chromosome Movement in Mitosis. $23,147 (one year renewal).

Robert D. Pike, William and Mary, Preparation and Elaboration of Novel (Cyclohexadienyl)manganese Complexes. $13,500 (one year).

James L. Riopel, University of Virginia, Cellular and Biochemical Basis of Host Resistance during the Penetration Phase of *Striga asiatica*. $13,000 (one year).

Emilie F. Rissman, University of Virginia, Multiple Forms and Functions of Gonadotropin-Releasing Hormone (GnRH). $22,210 (one year).

Patricia V. Rogers, Virginia Polytechnic Institute and State University, Glycogen Metabolism and Expression in *Dictyostelium*. $15,000 (One year renewal).

Paul K. Ross, Virginia Commonwealth University, Synthesis and Spectroscopic Characterization of Models for Nickel-containing Metalloenzymes. $14,095 (one year).

Margaret S. Saha, College of William and Mary, Determination and Patterning of the *Xenopus* Forebrain: The Role of *XeNK-2* in Anterior Neural Development. $17,200 (one year).

Bruce A. Sandow, Eastern Virginia Medical School, Carbohydrate-Mediated Sperm Binding in a Cell Adhesion Model. $16,352 (one year).

Jerzy Sarosiek and R. W. McCallum, University of Virginia, The Role of Esophageal Mucus-Lipid-Bicarbonate Complex in Mucosal Protection. $17,113 (one year renewal).

Brenda Winkel Shirley, Virginia Polytechnic Institute and State University, Analysis of protein-protein interactions in the *Arabidopsis* flavonoid enzyme. $30,746 (one year).

James M. Tanko, Virginia Polytechnic Institute and State University, Interplay of Structure and Reactivity in Atom Abstraction Reactions. $17,058 (one year renewal).

Michael P. Timko, University of Virginia, Immunological and Biochemical Studies of Protein Structure and Catalytic Activity in NADPH: Protochlorophyllide Oxidoreductases. $22,300 (one year renewal).

Brian M. Tissue, Virginia Polytechnic Institute and State University, Laser Spectroscopy of Probe Ions at Interfaces. $27,470 (one year).

Curtis G. Tribble, University of Virginia, Regional Spinal Cord Hypothermia and Adenosine for Prevention of Ischemic Spinal Cord Injury. $11,645 (one year).

Fang-Sheng Wu, Virginia Commonwealth University, Induction of Gene Expression for Binding Proteins by Calcium Perturbation in Germinating Pollen Cells. $14,250 (one year).

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VIRGINIA JOURNAL OF SCIENCE
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Vol. 45 No. 2 SUMMER, 1994

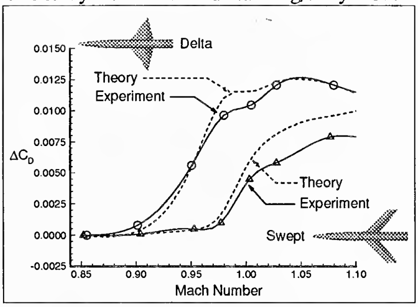
TABLE OF CONTENTS PAGE

ABSTRACTS OF PAPERS
72nd Annual Meeting of the Virginia Academy of Science
May 18–20, 1994, James Madison University
Harrisonburg, VA

Aeronautical and Aerospace Sciences

AN EVALUATION OF THE PERCEIVED URGENCY OF AUDITORY WARNING SIGNALS. Jennifer L. Burt and J. Raymond Comstock, Jr.*, NASA Langley Research Center, Flight Deck Research Branch - Mail Stop 321, Hampton, Va. 23681-0001; Debbie S. Bartolome* and Daniel W. Burdette*, Lockheed Engineering & Sciences Company, 144 Research Drive, Hampton, Va. 23666. One significant concern pilots have about cockpit auditory warnings is that the signals presently used lack a sense of priority. The relationship between auditory warning sound parameters and perceived urgency is, therefore, an important topic of inquiry in aviation psychology. The present investigation examined the relationship among subjective assessments of urgency, reaction time, and brainwave activity with three auditory warning signals. Subjects performed a tracking task involving automated and manual conditions, and were presented with auditory warnings having various levels of perceived and task urgency. Subjective assessments revealed that subjects were able to rank warnings on an urgency scale, but rankings were altered after warnings were mapped to a task-related urgency scale. Reaction times differed between automated and manual task conditions, and physiological data showed attentional differences in response to perceived and actual warning urgency levels. This study shows that the use of physiological measures, in conjunction with behavioral and subjective measures, can lead to the development of more effective auditory warning systems.

COMPARISON OF USM3D AND EXPERIMENT: HOW WELL DOES AN EULER CODE PREDICT TRANSONIC DRAG RISE? Wayne D. Carlsen, Joint Inst. For Advancement of Flight Sciences, George Washington Univ./NASA, Hampton, Va. 23665-5225. This study presents wave drag comparisons of experimental and theoretical results. The applied theory, USM3D, was an unstructured-grid Euler code. The experimental results came from the 1956 report by Dr. Richard Whitcomb on the development of the sonic area-rule. Two different experimental models from this study were used: A delta-wing/body model and a swept-wing/body model. The theoretical wave drag results from these two models were compared with the experimental results through the Mach number range 0.85 to 1.10. As shown in the figure, the results corresponded well. The results were exceptionally good when considering that boundary layer effects were neglected. Also, the largest discrepancies occurred near Mach one where experimental results were of questionable value. The comparisons showed that Euler theory predicts the trends in wave drag with reasonable accuracy. (Completed at NASA Langley Res. Ctr. under grant NCC1-24)



FOREIGN COMPETITION IN HIGH-SPEED RESEARCH: CAN THE U.S. MAINTAIN THE TECHNICAL EDGE?. Henri D. Fuhrmann, NASA Langley Research Center, Mission Analysis Branch, Mail Stop 406, Hampton, Va. 23681-0001. A review is presented of the unclassified literature concerning foreign high-speed research projects which pertain to the development of a High-Speed Civil Transport (HSCT). Motivation behind recent funding by Congress of HSCT development is the jobs, technology, and production potential of this expanding and lucrative market. If the United States can develop an economical HSCT that meets the environmental and regulatory constraints, the positive balance of trade resulting from the aerospace industry will be further bolstered. If indeed other countries are seriously pursuing similar ventures, it would be advisable to monitor technical and programmatic progress in order to gauge appropriately the level of investment required for this technology. The United States stands poised to meet the challenges and reap the benefits of the HSCT market. However, the U.S. must remain aware of foreign developments that may threaten the dominant position it has enjoyed in aerospace over the decades. (This work was completed as part of the George Washington University course requirements for a Master of Science Degree)

ON BI–GRID LOCAL MODE ANALYSIS OF SOLUTION TECHNIQUES FOR 3–D EULER AND NAVIER–STOKES EQUATIONS. S. O. Ibraheem and A. O. Demuren*, Dept. of Mech. Eng., Old Dominion Univ., Norfolk, VA 23529. A procedure is presented for utilizing the bi–grid stability analysis as a practical tool for predicting multigrid performance in a range of numerical methods for solving Euler and Navier–Stokes equations. For the Euler equations, bi–grid analysis is presented for three upwind difference based factorizations, namely Spatial, Eigenvalue and Combination splits, and two central difference based factorizations, namely LU and ADI methods. In the former, both the Steger–Warming and van Leer flux–vector splitting methods are considered. For the Navier–Stokes equations, only the Beam–Warming (ADI) central difference scheme is considered. In each case, estimates of multigrid convergence rates from the bi–grid analysis are compared to smoothing factors obtained from single–grid stability analysis. Effects of grid aspect ratio and flow skewness are examined. Both predictions are compared with practical multigrid convergence rates for 2–D Euler and Navier–Stokes solutions based on the Beam–Warming central scheme. In general, the bi–grid analysis gives better predictions of actual multigrid performance. (Supported by the NASA Lewis Res. Ctr. under Grant No. NAG–3–1329 with Dr. James Scott as Tech. Monitor. Computations were performed on supercomputers at NASA Lewis and NASA Ames Res. Ctr.)

COUPLED AND UNCOUPLED BENDING AND TORSIONAL VIBRATIONS OF VERTICAL TAIL BUFFETING. Osama A. Kandil and Steven J. Massey, Dept. of Aerospace Engineering, Old Dominion University, Norfolk, VA 23529. A simulation of tail buffet is presented for a delta wing-vertical tail configuration. Flow conditions are chosen such that the wing primary-vortex cores experience vortex breakdown and the resulting turbulent wake flow impinges on the vertical tail. The dimensions and material properties of the vertical tail are chosen such that the deflections are large enough to insure interaction with the flow, and the natural frequencies are high enough to facilitate a practical computational solution. This multidisciplinary problem is solved sequentially for the fluid flow, the elastic deformations and the grid displacements. The fluid flow is simulated by time accurately solving the laminar, unsteady, compressible, full Navier-Stokes equations using an implicit, upwind, flux-vector splitting finite volume scheme. The elastic vibrations of the tail are modeled by coupled bending and torsion beam equations. These equations are solved accurately in time using the Galerkin method and a five-stage Runge-Kutta-Verner scheme. The grid for the fluid dynamics calculations is deformed using interpolation functions to disperse the displacements throughout the computational domain. The results show that the vortex breakdown location is unsteady, asymmetric and sensitive to the vibrations of the tail. The addition of torsional vibration modes are seen to have a substantial effect on the tail response in comparison to the bending only case. The results also show that the deflections and loads of the coupled bending-torsion case are substantially lower than those of the uncoupled response case.

A WIND TUNNEL INVESTIGATION OF THE EFFECTS OF GURNEY FLAPS ON THE HIGH-LIFT CHARACTERISTICS OF A BUSINESS JET WING. Michelle T. Martuccio, The George Washington University, Joint Institute for the Advancement of Flight Sciences, NASA Langley Research Center, Mail Stop 355, Hampton, Virginia 23681-0001. Aircraft operations are both noisy and costly during the take-off and landing phases. High-lift systems can decrease the amount of airport noise and time to climb which saves fuel, as well as increasing overall payload and range. It is desired to have a simpler one- or two-element system that can achieve the same lift as a multi-element airfoil. Tests have been conducted in the NASA Langley 30- by 60- Foot Tunnel to determine the high-lift characteristics of .5%, 1% and 2%-chord Gurney flaps on a full-scale business jet. A Gurney flap is a small tab-like flap that extends perpendicularly down near a trailing edge surface, effectively increasing the camber of the airfoil. Flap settings of 10°, 20° and 30° were tested with the Gurney flaps both on and off. Comparing the longitudinal force data of these investigations show that the Gurney flap is an effective means of increasing lift; however, an increase in drag is noted in some circumstances.

A REFINED FIRST-ORDER, SHEAR-DEFORMATION THEORY AND ITS JUSTIFICATION. Yunqian 'Tim' Qi and Norman F. Knight, Jr., Dept. of Aerospace Engineering, Old Dominion Univ., Norfolk, VA 23529-0247. Using Pagano's exact solution for cylindrical bending problem of crossply laminated plates, the distribution of transverse shear strain is obtained which shows diversity, and discontinuity at dissimilar interfaces, through the thickness. In that sense, neither traditional first-order shear-deformation theory (FSDT) which takes transverse shear strain as a constant, nor most of the higher-order theories which are either based on or lead to continuous shear strain distribution, are adequate to account for actual response. A refined first-order, shear-deformation theory which retains the FSDT displacement assumption is proposed. The transverse shear strain derived from the FSDT displacement assumption, referred to as the nominal constant shear strain, is shown to be the stress-weighted-average shear strain through the thickness based on equivalent shear strain energy. Actual variational distribution of transverse shear strain is modeled which agrees with the stress distribution by constitutive relation pointwise. Without losing the simplicity of FSDT displacement assumption, the proposed refined theory not only shows improvement on predicting deflections, but also accounts for the actual variational distribution of transverse shear strain, for the first time, within the first-order shear-deformation theory. In addition, all boundary conditions, constitutive relations and equilibrium equations are satisfied.

APPLICATION OF A HIGHER-ORDER THEORY TO ORTHOTROPIC AND LAMINATED BEAMS. Christine C. Schleicher and Norman F. Knight, Jr., Dept. of Aerospace Engineering, Old Dominion Univ., Norfolk, VA 23529-0247. A higher-order theory and an associated finite element formulation are developed for analysis of laminated planar beams in bending. The higher-order theory incorporates both transverse normal stress and transverse shear stress, and is developed using two approaches. The first approach is based on assuming the transverse normal strain distribution to be a cubic function through the beam thickness, while the second approach is based on assuming the transverse normal stress distribution to be a cubic function through the beam thickness. In both approaches, the transverse shear strain distribution is assumed to be a quadratic function through the beam thickness. Theoretical and finite element results for these higher-order theories are presented isotropic, orthotropic and laminated beams in various loading conditions, and are compared with two-dimensional elasticity solutions. The higher-order theory produces accurate results for orthotropic beams in which the ratio of the longitudinal to transverse elastic moduli is less than five. Accurate transverse normal stresses are obtained provided the transverse elastic modulus is nearly constant through the thickness of the beam.

AN INBOARD-WING CONCEPT AS A HIGH-CAPACITY AIRPLANE. M. Leroy Spearman, NASA Langley Research Center, Hampton, VA 23681. The proposed concept consists of twin-bodies connected by an inboard wing. There are no outboard cantilevered wing panels as is the case for conventional designs. This arrangement provides for essentially doubling the passenger capacity of a typical single-body design for the same body length and for a width considerably less than the span of a single body design with outboard wing panels. It is anticipated that the wing, being a simple end-supported beam bounded by the bodies, would not be likely to bend or to twist and, as a result, might be much lighter than a conventional cantilevered wing with the same area. In addition, the wing chord could be much greater than that for a conventional wing and, for the same thickness ratio, could be much thicker. With this possibility, the wing could provide space for submerged engines or volume for fuel or cargo. This paper presents the results of a theoretical study of the aerodynamic characteristics of the concept for a Mach number of 0.80 with several variations in the wing span and chord for a constant wing area. Initial results appear favorable with lift-to-drag ratios being comparable to those for lower-capacity single-body designs.

PASSIVE CONTROL OF RANDOM RESPONSE OF SYMMETRICAL COMPOSITE PANELS USING SHAPE MEMORY ALLOYS AT HIGH TEMPERATURES. Z.W.Zhong, Center for Structural Acoustic and Fatigue Research, Department of Aerospace Engineering, Old Dominion University, Norfolk,Va 23529–0247. An investigation on reduction of random response of symmetrically laminated orthotropic plates with embedded shape memory alloy(SMA) fibers at high temperatures is presented. Stress-strain relations for a thin composite lamina with reinforced SMA fibers are derived. Governing equations including shape memory effects based on the classic continuum method are presented. The interesting buckling behavior that composite plates with SMA fiber reinforcement have two critical temperatures is revealed. Three types of analyses are performed, they are the thermal buckling, thermal postbuckling, and random vibration of thermally buckled composite laminates. The results of a simply supported rectangular panel demonstrate that the SMA fibers can completely eliminate the thermal postbuckling deflection and significantly reduce the random response at elevated temperatures.

Agriculture, Forestry and Aquaculture Science

NEW LEGUME CROPS FOR VIRGINIA. Harbans L. Bhardwaj, A. Mohamed, and M. Rangappa. Agricultural Research Station, Box 9152, Virginia State University, Petersburg, VA 23806.

In order to diversify Virginia's agriculture, a component of agricultural research at Virginia State University is focusing on development of new food, feed, and industrial use crops. Under this program, pigeonpea, chickpea, and mungbean are being evaluated as new legume crops to provide nutritious food for humans and animals and also for their nitrogen-fixing capabilities. During 1993, chickpea seed yields varied from 876 to 1400 kg/ha for eight *desi* types whereas the yield of 12 *kabuli* types varied from 307 to 1082 kg/ha. Chickpea also has potential as a vegetable crop, the green immature seeds are considered a delicacy by many people of Asian origin. Research conducted during 1992 indicated that determinate pigeonpea lines can yield upto 2042 kg/ha of mature seed. The average yield of three determinate lines (1751 kg/ha) was significantly higher than that of three indeterminate lines (721 kg/ha). The pigeonpea also has potential as a vegetable crop yielding upto 15,696 kg/ha of green (82.4% moisture) beans. The shelling percent of pigeonpea green beans varied from 52 to 55% with protein content of green seed varying from 18 to 21%. The evaluation of eight mungbean lines during 1993 indicated a considerable yield potential for this crop with yield varying from 1189 to 2068 kg/ha. These preliminary evaluations indicate that chickpea, pigeonpea, and mungbean have potential as new and alternate crops for Virginia.

TEMPORAL AND SPATIAL GENETIC VARIATION WITHIN AMERICAN SHAD (*Alosa sapidissima*) POPULATIONS OF MID-ATLANTIC RIVERS. B.L. Brown and T.C. Muller. Department of Biology, Virginia Commonwealth University, Richmond, VA 23284. Restriction endonuclease analysis of mitochondrial DNA was used to assess genetic variation of 649 American shad sampled from the Connecticut, Delaware, James, and Pamunkey Rivers (in CT, NJ, VA and VA, respectively) during 1991-1993. Haplotypes were incorporated into a Chi-Square analysis, using a Monte Carlo technique. Paired comparisons were made and genetic variation was not observed for some rivers within a given year, particularly 1991 and 1992 and genetic variation was observed in many rivers between years suggesting that sampling strategies are important when studying the spatial and temporal variations in a migratory species, such as the American shad.

MEAT GOATS: POTENTIAL FOR DIVERSIFICATION IN VIRGINIA AGRICULTURE. Terry A. Gipson & Stephan Wildeus, Agricultural Res. Station, Va. State Univ., Petersburg, Va. 23806. The demand for goat meat has risen dramatically over the last decade. Goat meat is very popular among the increasing ethnic populations in the United States. It has also attracted health conscious consumers who want to lower their dietary fat and still eat red meat. In the last ten years, the number of goats slaughtered in the United States has seen a substantial increase. However, domestic goat production is inadequate to meet the growing demand. The amount of chilled or frozen goat meat imported into the United States has seen a 70% increase over the last three years. Goats are growing in popularity with farmers who wish to diversify their operations, utilize marginal land or have limited resources. Goats have been used to control multiflora rose, kudzu, cedars, briars and other undesirable plant species in cattle pastures. This is because goats complement cattle in their grazing patterns with very little dietary overlap. The dietary preference of goats is 30% grass, 10% forbs and 60% browse. In contrast, cattle prefer 70% grass, 15% forbs and 15% browse. Thus, income may be improved by adding goats to a cattle operation. This may be true for some sheep enterprises too, because the grazing patterns of sheep and goats differ slightly. Sheep prefer 50% grass, 30% forbs and 20% browse. In addition to providing a desirable product for an ever expanding market, meat goats are valued for their contributions to nonchemical pasture renovation, multispecies diversification and low input farming.

EFFECTS OF FOOD PROCESSING ON THE NUTRITIONAL VALUE OF LEGUMES. Ali I. Mohamed. Agricultural Research Station, Virginia State University, Petersburg, Va 23806. Legume seeds are concentrated sources of protein with a particular value for direct utilization in the diet. Generally, the nutritional status of legume seeds are limited by poor digestibility, deficiency in lysine or sulfur containing amino acids and poor functional properties such as long cooking times and hard seeds. The objective of these studies is to determine the effects of several food processing on the nutritional value of faba bean which is considered to be one of the most consumed bean in third world countries. Dehulling process of faba bean seeds had no effect on protein content (26.9%). Total hydrolyzable carbohydrates was increased by dehulling (from 61.9% to 63.9%), while crude fiber was significantly decreased from 7.13% to 0.7%. By dehulling, tannin was significantly decreased from 139.18 to 64.49 mg/100 g. Phytic acid was increased by dehulling from 316.8 to 380.48 mg/100 g. Protein and carbohydrate digestibility was significantly increased by dehulling from 37.8 and 23.3% to 78.5 and 36.7% respectively. Glutamic acid was the predominant Non-Essential AA (18.34%) while lysine and leucine were the predominant significantlyEAA (7% and 8.67%). The effect of cooking on the chemical composition of faba bean seeds was also studied. Cooking decreased crude protein and total hydrolyzable carbohydrates due to leaching process. Cooking significantly increased protein and carbohydrate digestibility, from 73.8 and 23.3% to 88.04 and 56.49% respectively.

POND PRODUCTION OF CATFISH IN VIRGINIA. Scott H. Newton and M. David Crosby. Cooperative Extension Service, Virginia State University. Petersburg, VA 23806. During the 1992 and 1993 warm water production seasons, open pond culture of channel catfish, (Ictalurus punctatus), was examined in 0.25 acre research ponds located in Chesterfield County. The primary objective was to develop information on pond culture of catfish for the Mid-Atlantic Region. Both years, catfish were stocked similarly in triplicated ponds and fed once daily 116 of 151 days and 126 of 159 days, respectively. Fish stocking rates were 1500 and 3000 per acre in 1992 and 3000, 5000, and 8000 in 1993. In 1992, harvested catfish averaged 1.6 pounds, while 1993 average fish sizes were 1.2 for the 3000 and 5000 densities and 1.0 for the 8000 fish density. Gross harvest yields averaged 2175 pounds per acre for the 1500 fish per acre stocking, 4421 and 3372 pounds, respectively, for the two seasons with the 3000 per acre density, and 5328 and 6840 pounds per acre for the 5000 and 8000 stocking densities, respectively. Water quality management included aeration of ponds based upon monitored oxygen and other physicochemical parameters. Recommendations for pond catfish culture in the Mid-Atlantic Region are based upon management strategies and market sales outlets.

MEAT GOATS: MANAGEMENT CONSIDERATIONS FOR THE PRODUCTION OF MEAT. Stephan Wildeus & Terry A. Gipson, Agricultural Res. Station, Va. State Univ., Petersburg, Va. 23806. Goat production for meat differs from that for milk or for fiber in its reduced production intensity and increased emphasis on reproductive efficiency, kid growth rates and meat confirmation. Most of the goat breeds in the U.S. have been selected for either dairy production (Nubian, La Mancha, Swiss breeds) or mohair production (Angora), while neglecting maternal ability, and growth rate/muscling, respectively. Currently, the only true meat breed is the South African Boer goat that has recently been imported in the U.S. The Spanish goat, developed under extensive range conditions, the Tennessee Wooden-legged goat and the Pygmy goat are all smaller breeds, but have meat-type conformations and potential as components in a meat-producing crossbreeding scheme. For meat goat production to be efficient and profitable, animals must perform well under a forage-based system with limited inputs of harvested feeds. Females should be capable of giving birth to multiple litters with minimal assistance and successfully raise kids to weaning. Although goats generally are seasonal breeders, meat-type goats should ideally have extended breeding seasons or breed throughout the year. This would allow a decrease in kidding interval and allow breeding to produce kids for specific markets opportunities (i.e. Easter). No grading standards are currently adopted for goats and carcasses are marketed whole, but kids with good meat confirmation generally command higher prices. Hence selection and management for meat-type conformation and high growth rates should be pursued. To this end research is needed to characterize the meat production capacity of selected breeds and their crosses under Virginia production conditions and to refine meat goat management systems.

Archaeology

THE EXCHANGE OF COPPER DURING THE LATE WOODLAND PERIOD WITHIN VIRGINIA'S LOWER PIEDMONT AND RIDGE AND VALLEY: A CHANGE IN DIRECTION. Michael B. Barber, Preservation Technologies, Inc., P.O. Box 7825, Roanoke, VA 24019. Recent investigations at one site in the southern Piedmont and 2 sites within the Ridge and Valley of Virginia have indicated that European copper, as well as glass and shell beads and limited amounts of iron, was an important exchange item between the English Colonials and the Native Americans. Likely the local Indians would trade deer skins through a middleman arrangement for a limited array of European goods plus additional non-local Native American products. Although copper was an important indicator of Native American social status during the Late Woodland on the coastal plain of Virginia, there is little to suggest equal importance within the interior. Copper may have flowed from the interior to the coast during late prehistoric times but the trade was in the opposite direction at contact. Electron microprobe studies will be used to suggest possible copper sources.

A GUILFORD COMPONENT (ca. 3500-2200 B.C.) OF RHYOLITE AT FAIRWOOD HORSE CAMP NEAR MT. ROGERS, GRAYSON COUNTY, VIRGINIA: REVISITED. Eugene B. Barfield, Jefferson National Forest, Roanoke, VA 24019. Fairwood Horse Camp (44GY18) lies just over 4 miles northeast of the highest peak in Virginia, Mount Rogers, at 5,725 feet above sea level. The site itself is approximately 3,360 feet above sea level on a low valley interior stream floodplain. Over 90% of this lithic artifact assemblage is rhyolite and 91% of the diagnostics are Guilford (ca. 3500-2200 B.C.) representing the Late Middle Archaic. Quality comparisons will be made of this igneous material with other samples from the Middle Atlantic as well as a study of Middle Holocene ecological factors that may suggest the purpose of this weapon/tool manufacturing site in the subsistence scheme of the Late Middle Archaic Culture Period.

THE SMITH MOUNTAIN SITE; A DEEPLY STRATIFIED PALEOINDIAN OCCUPATION IN THE SOUTHWESTERN PIEDMONT OF VIRGINIA. William A. Childress, P. O. Box 124 Canal St. Sta., New York, N. Y. 10013 The Smith Mountain Site is a multicomponent Paleoindian/Early Archaic site located on the south floodplain of the Roanoke River near its constriction at Smith Mountain Gap. A hydroelectric complex created by the impoundment of Smith Mountain and Leesville Lakes in the 1960's has resulted in considerable erosion of alluvial features below the dam at Smith Mountain where two lithic concentrations have been exposed at the head (44PY7) and foot (44PY152) of a natural levee located on what is now the margin of Leesville Lake. This levee documents a sedimentary buildup throughout the Holocene and is underlain by a cobble lens(es) apparently representing late Pleistocene point bar deposits upon which the earliest recognized occupation of the site commenced. Lithic forms representing virtually the entire range of Paleoindian tool types including fluted points have been recovered on the sites' lower levels with transition Paleoindian and Early Archaic projectile points occurring somewhat higher. Auger tests have confirmed an early occupation zone from 1.5-1.95 m at 44PY7 and 1.8-2.5 m at 44PY152. Recoveries of cultural material in the matrix at considerably lower levels suggest even deeper stratification. The Smith Mtn. site is the most deeply buried fluted point site recorded for Va. and perhaps for the Southeast as well. As the first Paleoindian residential site recorded for southwest Va., it may be indicative of a riverine oriented settlement focus in the region. Similar sites may be more common on higher order streams in the piedmont than has been realized. The dispersed and numerous sources of the assemblage's high quality lithic materials and substantial use of coarser local lithics for expedient tools at Smith Mtn. may modify some of Va.'s quarry weighted models of Paleoindian reliance on cryptocrystallines

THE LANDSCAPE DESIGN AT EPPINGTON PLANTATION: THE INTERSECTING SPHERES OF BLACKS AND WHITES. Garrett R. Fesler, James River Institute for Archaeology, Inc., 2080 Jamestown Road, Williamsburg, Va. 23185. Recent archaeological excavations at Eppington plantation in Chesterfield County have revealed new information about a distinctive late 18th-century plantation landscape. Francis Eppes began building Eppington in the early 1770s and continued to modify his house and surrounding grounds until his death in 1808. In its heyday Eppington was the most productive plantation in Chesterfield County with over 40 slaves living and working on the property. Supplemented by several important documentary accounts, and comparative data from Monticello, Mount Vernon and elsewhere, archaeological excavations have uncovered a dynamic plantation landscape design at Eppington intended to function both as an economically efficient estate and as a purposefully ornate symbol of power and community authority. Although Eppes attempted to conceal the working world of his slaves from view, archaeological work has allowed them to reclaim their place on the Eppington landscape. Archaeological findings demonstrate that Eppes was unable to segregate the earmarks of daily toil from his carefully shaped aesthetic landscape.

PASPAHEGH ARCHAEOLOGY: REPORT ON INVESTIGATIONS AT SITE 44JC308, A PROTOHISTORIC/EARLY CONTACT NATIVE AMERICAN VILLAGE IN JAMES CITY CO., VA. Mary Ellen N. Hodges and Charles T. Hodges, James River Inst. for Archaeology, Inc., 2080 Jamestown Rd., Williamsburg, Va. 23185. Recent areal excavations conducted within a 2.1-acre section of site 44JC308 documented 48 structural patterns and 25 human mortuary features associated with a Native American village occupied during the late 16th/early 17th centuries, likely by the Paspahegh Indians. Diverse lines of evidence have been used to define the internal structure of the settlement and the nature of socio-political organization, ideological systems, health, and subsistence within the local population. The multi-disciplinary investigation involved ethnobotanical and zooarchaeological analysis of subsistence debris, biocultural and stable isotope analysis of human osteological remains, identification of the composition and fabric structure of organic materials associated with the burials, and compositional and metallographic analysis of copper-base funerary artifacts. Site 44JC308 is located about six miles upriver from Jamestown, the first permanent English settlement in North America, and is significant for determining the consequences of European contact for the native inhabitants of the Virginia Coastal Plain during the early years of colonial settlement in the Chesapeake region.

AN ARCHAEOLOGICAL ASSESSMENT OF THE J.E.B STUART BIRTHPLACE PATRICK COUNTY, VIRGINIA. Clifton A. Huston, William and Mary Center for Archaeological Research, College of William and Mary, P.O.Box 8795, Williamsburg, VA 23187. During the month of November, 1993, an archaeological assessment was conducted at the property that is believed to have been the birthplace of General J.E.B. Stuart, in Patrick county, VA. This assessment was performed for the J.E.B. Stuart Birthplace Trust, located in Stuart, VA. The project included mapping, controlled surface collection and limited subsurface investigation of a disced agricultural field located on a ridge overlooking the Ararat River. Two previously unknown archaeological sites were located during this assessment. 44PK112 is an Early and Middle Archaic lithic site, and 44PK113 is a multicomponent site that contains an Archaic occupation that is overlain by the historic Stuart housesite. Surface collection of this site produced artifacts and data that point to the location of two structures, one of which appears to have been destroyed by fire, in the same manner as the Stuart house in the winter of 1847-1848.

"THE RUDIMENTS OF A SCIENTIFIC APPROACH:" ROLAND WELLS ROBBINS AND THE DEVELOPMENT OF METHODOLOGY IN HISTORICAL ARCHAEOLOGY. Donald W. Linebaugh, Dept. of Anthro., Col. of William and Mary, Williamsburg, Va. 23185. Roland Robbins presents an enticing study of the disciplinary evolution of historical archaeology, through an extraordinary career that began with the excavation of Thoreau's cabin in 1945 and expanded to include sites throughout the northeastern U.S. Understanding historical archaeology's development as a discipline is very important when reevaluating the work of previous archaeologists. Current scholars, by dismissing early figures like Robbins because of their "imperfect techniques and antiquarian goals," have overlooked valuable archaeological evidence. For instance, Robbins work at Saugus Ironworks, Philipsburg Manor Upper Mills, Shadwell, and particularly the John Alden House, is remarkable for the way in which Robbins's techniques and methodology resembled those of the burgeoning discipline of historical archaeology. He used grid systems for horizontal control, probe or shovel testing for site survey, and refined artifact provenience controls. Perhaps most surprising was his early use of special analytical studies, such as c14, soil analysis, bone analysis, tree ring dating, materials analysis, and artifact conservation. These studies, it seems, gave Robbins confidence and legitimacy in the face of increased pressure from the academic community.

SITE BURIAL FOR DATA PRESERVATION. Craig Lukezic and Antony Opperman, Virginia Department of Transportation, 1401 East Broad Street, Richmond, Virginia 23219. Site Burial is a controversial alternative to excavation for mitigation of construction impacts. As a community, archaeologists of Virginia are wary of the long term effects of site burial as unintentional site burial has damaged fragile and organic artifacts in the past. Currently, the Virginia Department of Transportation is developing a procedure to minimize data loss and enhance site preservation through intentional site burial.

THE ARCHAEOLOGICAL INVESTIGATION OF A LATE-NINETEENTH/EARLY-TWENTIETH CENTURY AFRICAN-AMERICAN SITE IN MONTGOMERY COUNTY, VRIGNIA. Cara Harbecke Metz, P.O. Box 1191, Williamsburg, Va. 23187. The Phase II archaeological evaluation of Site 44MY463 in Montgomery County, Virginia, was conducted by the William and Mary Center for Archaeological Research in the spring of 1993 under an agreement with the Virginia Department of Transportation. This investigation resulted in the recovery of data regarding the material life of a Post-Bellum, African-American tenant family. Documentary and ethnohistorical research provided additional information regarding the occupants of the site as well as data regarding life in an African-American community in the New River Valley of Virginia. The results of this investigation will be discussed and the broader issues regarding the study of late-nineteenth/early-twentieth century archaeological sites will be addressed.

"IN THE HILLY COUNTRIES BY SMALL RIVERS": DOCUMENTING THE ARCHAEOLOGY OF VIRGINIA'S NORTHERN PIEDMONT. Carole L. Nash, Dept. of Soc./Anth., James Madison Univ., Harrisonburg, Va. 22807. Since 1990, the Madison Archaeology Project (MAP), the first county-wide public archaeology program in rural Virginia, has recorded 300 prehistoric and historic sites in Madison, Greene, and Rappahannock Counties. From its western boundaries of 4000' a.s.l. Blue Ridge peaks, to its eastern boundaries of 300' a.s.l. Triassic Basin floodplains, this region is characterized by impressive environmental diversity whose use is reflected in Native American settlement choices. Sites ranging in age from the Paleo-Indian through the Late Woodland periods have been documented in this first systematic archaeological study of the northern inner Piedmont. The preliminary culture history developed out of this work raises questions about the association of Native American populations of the inner Piedmont to those of the larger Central Virginia and Shenandoah Valley regions.

I SEE WONDERFUL THINGS BENEATH THE FILL: PHASE II TESTING AT A LATE WOODLAND VILLAGE (44MY7) ON THE NEW RIVER, MONTGOMERY COUNTY, VIRGINIA. Stevan C. Pullins, Ctr. for Archaeological Res., Col. of William and Mary, P.O. Box 8795, Williamsburg, VA 23187-8795. Construction at the Radford Army Ammunition Plant has impacted a Late Woodland village on the New River. Phase II testing revealed that significant portions of the site are still present beneath thick layers of fill and spoil, including pit features, posthole and structure patterns, and midden deposits. Extensive faunal and floral remains were recovered from midden deposits and feature fill. The ceramic assemblage was comprised of Radford, Dan River, and New River types. Radiocarbon dates from carbonized maize indicated that the primary occupation of the site took place during the 13th and 14th centuries A.D.

THE DOGUE RUN SURVEY: SEARCHING FOR GEORGE WASHINGTON'S SIXTEEN-SIDED BARN. Suanna C. Selby, Dept. of Archaeology, Mount Vernon Ladies' Association, Mount Vernon, Va. 22121. A survey to locate and define the site of the 16-sided barn built by George Washington at his Dogue Run Farm in 1792-94 was completed in the summer of 1993. In conjunction with plans to implement an agricultural interpretive program centering on a reconstructed barn, the Mount Vernon Ladies' Association Department of Archaeology performed the intensive survey to answer specific questions about the structure. Now located outside the present boundaries of the Mount Vernon estate, the barn was identified in a neighboring residential area. Computer manipulation of several historic maps enabled pinpointing of the site to within a two-acre area. Systematic excavation of shovel test pits and test units revealed two concentrations of overfired and underfired brick fragments. One heavy concentration, containing a stratum of brick rubble, is interpreted as a brick clamp. The second concentration, in an area with the highest probability for containing the site, is located next to a house and swimming pool. The available evidence suggests that the barn and barnyard are concealed by the modern features of the neighborhood.

PROTON MAGNETOMETER AND GRADIOMETER SURVEYS OF 3 HISTORIC CEMETERIES. Michael A. Strutt Corporation For Jefferson's Poplar Forest. P.O. Box 419 Forest, Va. 24551. The usefulness of the proton magnetometer and gradiometer in archeological survey have been amply demonstrated in the past few decades. But the instruments are still not widely used by archeologists. The advantage of this remote sensing technique to non-invasive survey and the time saving capabilities should not be overlooked. The relative inexpensiveness of the instruments and ease of use, make them ideal for survey. When the magnetic situation is not suitable for the magnetometer because of modern disturbances, the gradiometer can filter out the detrimental effects of the disturbances. These concepts will be demonstrated by the presentation of three surveys showing the various types of magnetic anomalies created by historic graves and how they can be detected, even when utilities and automobiles are in the magnetic field area.

HIGHWAYS AND BRIDGES, BRIDGES AND HIGHWAYS: A REVIEW OF CULTURAL RESOURCE ACTIVITIES IN THE VIRGINIA DEPARTMENT OF TRANSPORTATION'S RICHMOND DISTRICT. J. Mark Wittkofski, VDOT, Richmond District Environmental Section, P.O. Box 3402, Colonial Heights, Va. 23834-9002. This paper presents an overview of archaeological research which has been conducted on transportation-related projects during the last 28 years in the 14 central and south-central Virginia counties and the city of Richmond which comprise the VDOT Richmond District. A total of more than 125 studies have been completed, however, time restrictions have limited the scope of this presentation to the discussion of only a handful of recent projects. These projects include research conducted both by VDOT staff and consultants. The studies presented in this paper include research from prehistoric Native American Early Archaic period camp sites, dating to ca. 7500 B.C.,to post-Civil War Anglo-American urban communities and free black-occupied rural farmsteads. This VDOT-sponsored archaeological research has contributed a tremendous amount of data which continue to be analyzed and synthesized in order to present a more accurate and complete understanding and interpretation of Virginia's cultural past.

Astronomy, Mathematics and Physics

MODELING AIR FRICTION IN PROJECTILE MOTION. Richard L. Bowman & David L. Pugh*, Dept. of Physics, Bridgewater College, Bridgewater, VA 22812. Theoretical models for air friction on projectiles in free fall and in two-dimensional trajectories are developed using *Mathematica*'s capabilities in plotting, curve fitting, algebra and calculus. The two models examined are for friction depending linearly on the speed of the projectile and depending on the square of the speed. Experimental data for a steel ball and a cork ball are compared to the results obtained from applying the theoretical models. Air friction appears to be a significant factor in the cases presented.

A HIGH SCHOOL PHYSICS TEACHER WORKSHOP AND STUDENT OLYMPICS IN CHINA. D. Rae Carpenter, Jr., Dept. of Physics & Astronomy, Va Military Inst., Lexington, VA 24450. Nanjing Normal University, Nanjing, Peoples' Republic of China, offers a summer workshop for junior and senior high school teachers followed by a day-long olympics with local students in Grade 6-9 plus another day for Grade 10-12. Following the U.S.-Japan-China Conference, supported by AAPT, in Zhaoqin, CHINA, the author accompanied another conference participant, Prof. Liu Bingsheng, to Nanjing and participated in Liu's workshop- olympics for a week in August. Much of the teacher workshop is built around demonstrations using simple materials readily obtained in China. The program included a video session and a commercial exhibit. Demonstrations were presented by Carpenter, Liu and some of the participants. The academic portion of the student olympics was done in game show format by 6-12 competing teams from different schools with 6 persons per team. The teams viewed about a dozen live and taped demos and answered questions about each, some of which required the drawing of a diagram. The latter part of the morning was devoted to construction of devices to be used in the afternoon competition. Slides will illustrate teacher activities and examples of both junior and senior olympics. While some of the events were similar in concept to ones done in the U.S., the lack of sophisticated materials provided challenging variations. The teachers, the students and the physics were outstanding, but done under very trying economics conditions.

CHARACTERIZATION OF SOME MIXED LIGHT-METAL HYDRIDES. C. M. Castevens and S. L. Herr, Department of Physics, Virginia Commonwealth University, P.O. Box 842000, Richmond, Va. 23284-2000. Recently it was suggested that $LiBeH_3$ and Li_2BeH_4 may have properties similar to the properties of the proposed metallic and superconducting phase of hydrogen, and as such they may be candidates for high temperature superconductivity. Since then, several researchers have chosen to study $LiBeH_3$ with cluster calculations. Though the papers disagree with each other on both atomic and electronic structures, all have agreed that $LiBeH_3$ is an insulator. More recent calculations suggest that replacing beryllium with other elements would turn $LiBeH_3$ from an insulator to a metal, which has lead to theoretical studies of Li_3AlH_6, Li_3BH_6, and other hydrides. We have characterized several hydrides by vibrating sample magnetometry and temperature dependent ac susceptibility to determine their magnetic properties, several for the first time. Attempts at making the new compound Li_3BH_6 are also described.

MICROSTRUCTURAL PROPERTIES OF HIGHLY NITROGENATED MECHANICALLY ALLOYED IRON POWDER. Desmond C. Cook and James C. Rawers*, Department of Physics, Old Dominion University, Norfolk, VA 23529. *U.S. Bureau of Mines, Albany Research Center, Oregon 97321. Iron powder has been mechanically alloyed for up to 250 hours in a nitrogen gas environment in order to investigate the microstructural changes due to nitrogen infusement. The same powder was also alloyed in an argon gas environment in order to isolate the microstructural changes due purely to cold working from those due to the interstitial nitrogen. Samples were analyzed for particle size distribution and nitrogen concentration. This was followed by x-ray analysis to identify the phases present, lattice parameters and internal strain. Mössbauer analysis was performed to study the microstructural magnetic properties and to identfy the phases present. We have determined that nanocrystalline bct Fe-N martensite has formed from the bcc-Fe after 50 hours of mechanical processing. For the first 50 hours of processing both the internal strain and interstitial nitrogen concentration increased linearly. At 50 hours, the crystallite size was reduced to about 100Å and the highly strained nanocrystalline structure contained several atomic percent of nitrogen. Additional mechanical alloying resulted in a supersaturated, highly strained nitrogen bcc-Fe structure. This locally induced strain was suddenly reduced by formation of the bct Fe-N martensite through local redistribution of some of the highly mobile nitrogen atoms.

DETECTOR DEVELOPMENT AT JAMES MADISON UNIVERSITY. Darren Ellis, Dr. Kevin Giovanetti, Department of Physics, James Madison University, Harrisonburg, Va. 22807. Operation of an automated calibration system requires that the system be interfaced to some type of computer control. The calibration system being developed at JMU for the forward electromagnetic calorimeter at CEBAF will be interfaced within the framework set forth by the data acquisition and slow controls being developed for the CLAS detector. A brief overview of the slow controls and a discussion of the design issues that we face in interfacing our calibration system will be given.

IDENTIFICATION OF THE IRON-ZINC PHASES IN COMMERCIALLY PRODUCED GALVANNEALED STEEL. R.G. Grant and D.C. Cook, Old Dominion University. A recently compiled data-base of the lattice and Mössbauer parameters of the pure Fe-Zn intermetallic phases has aided in the study of many commercially produced galvanneal coatings using XRD, conversion electron (CEMS), and transmission Mössbauer spectroscopy. The results show that different amounts of the four Fe-Zn phases are present in each coating depending on the production conditions. Also, a layering of the phases in the coatings was observed with predominantly the ζ or δ phase at the surface and a high iron concentration Γ phase forming as a very thin layer at the steel-coating interface. Comparing coatings produced with Al added to the Zn bath with those produced in Al-free baths show that the Al suppresses the formation of the ζ and low iron δ phase. We have also fractured many coatings in order to investigate the failure point within the coatings. CEMS of these coatings has shown that, following coating fracture, no Fe-Zn phases are left on the steel substrate. These observations are of industrial importance and warrant further study into the powdering characteristics of each phase to determine if steel surface preparation prior to galvannealing affects the coating adhesion and longevity. (Supported by International Lead Zinc Research Organization, Inc. grant ZM-403 and Virginia's Center for Innovative Technology grants MAT-92-007 and MAT-93-018.)

THE LORENTZ EQUATIONS: DERIVATION AND SOLUTION. R. Douglas Hyman, Department of Mathematics, Virginia Union University, Richmond, VA 23220. A numerical experiment has been conducted on the Lorentz model which describes the interrelation of temperature variation and convective motion in a fluid. The Lorentz equations governing "roll" convection between two surfaces maintained at a constant temperature difference are derived. A numerical method for solutions from an initial condition is given. These solutions for a fixed Prandtl number and variable normalized Rayleigh numbers are displayed graphically in phase space and exhibit the behavior common to dissipative dynamical systems, namely the convergence of all trajectories towards an attractor.

FLUID MECHANICAL EFFECTS OF TORTUOSITY IN ARTERIAL BLOOD FLOW. Kenneth C. Jacobs, Dept. of Physics, Hollins Col., Roanoke, VA 24020. Working during 1992 and 1993 with Dr. Bruce A. Young (Biology), Mr. Robert H. Hansen (Computer Science), and four Hollins undergraduates, we constructed and experimentally verified a theoretical model to examine the influence of different arterial configurations (tortuosity) upon blood pressure rise and arterial extensibility. I will present the model equations, which cover both laminar and fully-turbulent flow, as well as our parameterization of geometrical tortuosity. Results will be summarized for multiple bends, loops, and helices. The experimental setup to verify the model will be described and critiqued. This is one example of interdisciplinary biophysics research underway at Hollins College.

MOSSBAUER AND X-RAY STUDY OF THE IRON NITRIDE, Fe_4N. Tae H. Kim, Desmond C. Cook and James C. Rawers*, Department of Physics, Old Dominion University, Norfolk, VA 23529. *U.S. Bureau of Mines, Albany Research Center, OR 97321. Nitrided steels are well known for their very hard and wear-resistant characteristics. One nitride that is commonly observed in high nitrogen steels is ferromagnetic Fe_4N which is found to precipitate as a result of the low nitrogen solubility in steel and other iron alloys. X-ray diffraction measurements on pure Fe_4N shows it to have a face-centered cubic arrangement of iron atoms with nitrogen at the body-center position. Its lattice parameter has been calculated to be 3.79A. Mossbauer spectra recorded at 300K and 78K show that there are three iron sites (Fe I, Fe II-A and Fe II-B) in Fe_4N. The relative alignment of the magnetic hyperfine field and electric field gradient at each site will be presented.

ELECTRONS, PHONONS, AND PHOTONS IN SOLID-STATE HETEROSTRUCTURES AND OTHER FABRICATIONS. Peter A. Knipp, Dept. of Physics and Comp. Sci., Christopher Newport Univ., Newport News, VA 23606. To study the fundamental excitations of structures such as semiconductor nanostructures, electromagnetic waveguides, or concert halls, it is necessary to solve their equations of motion. This involves solving equations of the form of either Helmholtz's equation or Laplace's equation, along with appropriate boundary conditions at interfaces separating different media. Except for highly symmetrical shapes these equations are "nonseparable" and hence cannot be solved analytically. I show that these can be simplified using Green's function techniques and that the resulting integral equation can be solved straightforwardly using matrix methods. The present method is contrasted with the more versatile but less efficient "finite elements" method. The electromagnetic modes of a microwave cavity are calculated and shown to be in excellent agreement with the results of a recent experiment. I also show results for the electronic states of a "modulated-barrier" quantum wire and the vibrational states of an acoustic waveguide. (Collaboration with T. L. Reinecke. Supported in part by the U. S. Office of Naval Research.)

PREPARATION, PROPERTIES AND APPLICATIONS OF $ZnO-SiO_2$ THIN FILMS. David J. Lawrence, ISAT Program, James Madison Univ., Harrisonburg, VA 22807. $(ZnO)_x(SiO_2)_{1-x}$ thin films were prepared on a variety of substrates by metalorganic chemical vapor deposition, using silane, dimethylzinc and oxygen as the reactants. The film compositions were determined by Rutherford backscattering spectrometry. The films were also characterized by x-ray diffraction, UV-visible spectrophotometry and ellipsometry. $(ZnO)_x(SiO_2)_{1-x}$ films were used as diffusion sources in the fabrication of light emitting diodes, photodiodes and laser diodes. For these applications, $(ZnO)_x(SiO_2)_{1-x}$ was deposited on semiconductor wafers. Heating the coated wafers to 600-800°C caused zinc to diffuse from the $(ZnO)_x(SiO_2)_{1-x}$ film into the underlying semiconductor, producing a p^+ doped layer.

THE CHALLENGES OF PHYSICS TEXTBOOK PHOTOGRAPHY. Jim Lehman, Department of Physics, James Madison University, Harrisonburg, Virginia, 22807. Color textbook photography is primarily a trial and error process. Involved are experimental front lighting, back lighting, the general background and color considerations. Action shots must use short exposure times and techniques such as fluorescent paint flooded with black light or strobe techniques. Optics shots call for rays illuminated by colloidal dispersion or smokebox techniques. There is a need for good communication between the photographer and the publisher. At times the people working with text setup with the publisher have little understanding of the illustrative material.

AN INTRODUCTION TO FERMAT'S LAST THEOREM. J. Larry Lehman, Department of Mathematics, Mary Washington College, Fredericksburg, Va. 22401. This presentation is designed as a general introduction to the mathematical background needed for Andrew Wiles' recently announced proof of Fermat's Last Theorem—elliptic curves, modular forms, and Galois representations—along with a broad outline of the strategy of Wiles' proof.

MATHEMATICA, CALCULUS AND REFORM AT VIRGINIA TECH; A STATUS REPORT FROM A GRADUATE STUDENT'S PERSPECTIVE. Xiaoguang Li and Robert F. Olin, Department of Mathematics, Virginia Tech., Blacksburg, VA 24061-0123. During the last year, the mathematics department has incorporated the use of Mathematica into several of its calculus classes. Some classes are taught in a computer lab, while others are given in rooms equipped with multi-media capability. The presenter along with his adviser have incorporated this technology in the multi-variable and series course. Some observations and comments from a graduate student's perspective will be given, as well as some of the examples being used in the class.

THE GREENBANK TELESCOPE. Dr. Felix J. Lockman, NRAO, POBox 2, Green Bank WV 24944. The Green Bank Telescope (GBT), now under construction at the National Radio Astronomy Observatory in Green Bank, WV, will be the world's largest fully steerable radio telescope upon its completion in early 1996. This talk will provide an overview of the GBT project, from its inception in the ruins of the collapsed 300-foot telescope, to a description of the experiments that the telescope will most likely perform. The GBT is unique in many aspects: it is an offset reflector to minimize scattered radiation; its surface is under active control to maintain a precise reflector shape; the telescope will operate over a larger range of frequencies than any other radio, infrared or optical telescope. Among the technical challenges of this project is the need to make the >2 acre surface conform to a parabolic shape within an rms error of <0.5 mm, and the need to control telescope positioning and tracking to within 1" under ambient weather conditions. The Green Bank telescope is expected to make major advances in our understanding of pulsars, interstellar chemistry, and cosmology.

CALIBRATING THE ELECTROMAGNETIC CALORIMETER FOR THE CEBAF LARGE ACCEPTANCE SPECTROMETER. Dustin E. McNulty, Dr. Kevin Giovanetti, Department of Physics, James Madison University, Harrisonburg, Va. 22807. The electromagnetic shower calorimeter (EMC) is a large detector covering the forward regions of the CEBAF Large Acceptance Spectrometer (CLAS detector). The EMC will employ photomultiplier tubes (pmt's), together with plastic scintillators, to measure the energy of particles involved in high energy collisions at CEBAF. The ability to measure reliably the energy of these particles is linked directly with the stability of the pmt response. To ensure the reliability of energy measurements, the calorimeter must be routinely monitored. The method of monitoring and calibrating the EMC will employ real events in conjunction with a calibrating/monitoring system. The calibrating/monitoring system consists of a pulsed UV laser and a network of optical fibers. This system is designed to deliver a measured light pulse to certain detector components and will be employed to regularly monitor these components. By combining the response of the components from both real events and calibration events, the absolute detector response can be determined.

HOW STANDARD DEVIATION OF DATA DEVIATES FROM STANDARD DEVIATION OF THE MEAN", Joseph D. Rudmin, Physics Dept., Univ of Virginia 22904 & Joseph W. Rudmin, Physics Dept., James Madison Univ., Harrisonburg, 22807. The standard deviation of the mean for combined data sets, S=sqrt(1/ sum(1/s(i)^2)), does not take into account variation in the means of the data sets. As a result, the standard deviation of the data can be significantly larger than the standard deviation of the mean. This paper presents a simple exact formula for the standard deviation of the data, explains how the derivation of the standard deviation of the mean differs, and explains why the standard deviation of the mean is usually quoted instead of the standard deviation of the data.

ASTEROID HUNTING WITH A 14-INCH TELESCOPE AND A SMALL-SOLID-ANGLE CCD. Joseph W. Rudmin and Geoffrey Williams, Physics Dept., James Madison Univ., Harrisonburg, VA 22807. The JMU Physics Dept. has acquired a Lynx Charge-Coupled Device (CCD) for installation on the 14-inch Telescope at the department's observatory at Stokesville, VA. The CCD is an array of photodetectors which can deliver a high resolution image displayable on a computer monitor. This talk will present the feasibility of using the CCD and telescope to search for previously unclassified asteroids. The sensitivity and estimated discovery rate will be discussed. A necessary part of the project is to compute the trajectories of known asteroids. The approached used will be the implementation of the Picard iteration developed by Edgar Parker and James Sochacki of the JMU Mathematics Dept. (Supported by the LaRose Fellowship awarded by the James Madison University Foundation.)

DISCHARGE CIRCUIT IMPROVEMENT FOR HARD-CORE FLASHLAMP BLUE-LASER SYSTEM[1] Jae Tae Seo, Kwang. S. Han and Ja H. Lee,[2] Dept of Physics, Hampton University, Hampton, VA 23668. An attempt has been made to improve a Hard-Core-Flashlamp (HCF)-pumped blue laser system. The operating conditions of the HCF were following: the input electrical energy to HCF was 289 J, argon fill gas pressure 600 torr. The concentration of Coumarin 460 dye was 1.25×10^{-4} mole/liter in the ethyl alcohol. The peak current and its risetime in the HCF were improved to be 25.5 kA and 0.42 μs with the input energy of 144 J as compared with the previous values 16.6 kA and 1.22 μs, respectively. The pump pulse had a halfwidth of 2.68 μs, and a risetime of 0.68 μs. The output laser pulse (451± 2.4 nm) had a halfwidth of 1.38 μs, and a risetime of 0.16 μs. The system improvement was mainly made by reducing the inductance of the transmission line and adapting a multipin triggered inverse pinch switch. The use of the HCF-pumped Coumarin 460 laser for bathymetry and underwater laser communication links is discussed.

[1] Work is supported by ONR grant N00014-89-1653

[2] Adjunct Professor, Sr. Scientist, NASA Langley Research Center

PREPARATION OF THIN FILMS BY LASER ABLATION. T. S. Sherwood, S. L. Herr, D. P. Pappas and C. M. Castevens, Va. Commonwealth Univ., Dept. of Physics, P.O. Box 842000, Richmond, Va. 23284-2000. The objective of this project is to produce thin films of $YBa_2Cu_3O_{7-x}$ (Y123) and other high temperature superconductors using the laser ablation technique. This technique will incorporate the use of an existing high vacuum chamber and a pulsed Xe-Cl excimer laser. We have designed internal modifications of the chamber for this application. Thin film deposition will be accomplished by utilizing a Y123 ceramic pellet as the target of the laser which will be incident at 45 degrees. The ablated stoichiometric material will condense on heated $SrTiO_2$ or MgO substrates located directly above the target. Prepared samples will be characterized and tested for use in future bolometric measurements to investigate optical and electronic properties near the superconducting transition temperature.

LATE 19TH CENTURY WORLD'S FAIRS; AN INTRODUCTION FOR LATE 20TH CENTURY STUDENTS TO PHYSICS, AND TO ITS PROMISE AND PROBLEMS. Jane C. Webb and George R. Webb. Dept. of Physics and Computer Science, Christopher Newport University, Newport News, VA 23606. Charlotte Webb, Science Studies, Virginia Polytechnic Institute & State University, Blacksburg, VA 24060.
World's Fairs of the late 19th century were the first places many citizens encountered the dramatically emerging science of physics, and for many of them what they saw changed their lives. American families traveled from all over the country to the World's Columbian Exposition in Chicago in 1893 and stood in awe in front of the huge machines that were the centerpieces of the Electricity Building and gave evidence to these citizens of the power of their new nation. Henry Adams, overwhelmed by what he saw at the Great Exposition of 1900 in Paris, wrote of his new vision. The transforming power of the dynamo was to replace the spiritual idealism represented in the power of the Virgin Mary. The excitement generated by these scientific and technological artifacts of the end of the 19th century teaches today's students about the interconnections between advances in science and the spirit of the times; understanding of the operation of the artifacts themselves assists in creating excellent illustrations for physical theories.

SECOND HARMONIC GENERATION OF DIODE LASER PUMPED Nd:YAG LASER WITH KTP CRYSTAL. Jie Zhou and In H. Hwang, Physics Department, Hampton University, Hampton VA 23668. An experiment was performed to generate the second harmonic radiation from a diode laser end-pumped Nd:YAG laser. A semiconductor diode laser of output power up to 1 W at 791 nm was used to pump the Nd:YAG laser rods of length 10 mm and 15 mm. Two different lengths of KTP crystal were used for the second harmonic experiment. When the 10 mm long KTP crystal was inserted in the laser cavity in series with the 10 mm long Nd:YAG crystal, the second harmonic output power of 2.3 mW was measured at 532 nm. The detailed experimental setup and results will be presented. (Work supported by NASA grant NAGW-1-2929)

Biology

CHROMOSOMAL COMPARISONS IN TWO POPULATIONS OF *CLETHRIONOMYS GAPPERI*. M. Josephine Babin[a] and Ralph P. Eckerlin[b], [a]George Washington University Hospital, Wilson Genetics Unit, Ross Hall, Room 455, 2300 I St. NW, Washington DC 20037; [b]Natural Sciences Division, Northern Virginia Community College, Annandale, VA 22003. Specimens from two populations of *Clethrionomys gapperi* were karyotyped, G-banded, and analyzed for differences in banding patterns. The resolution achieved was not sufficient to reveal subtle variations and did not yield any major differences. Both animals had a modal number of 56 which is the diploid number characteristic for the genus. One each of male and female metaphases were suitable for karyotyping. Improved karyotypes are necessary to determine if the two populations differ at the cytogenetic level.

COMPARISON OF WING MORPHOLOGY OF BATS ON DOMINICA. Oliver Bauer, Biology Department, Shenandoah University, Winchester, VA 22601. Twelve species of bats have been reported from the Caribbean island of Dominica. These species differ in their diet, most being either insectivorous or fructivorous. My observations in the field suggested that insectivores had narrow, pointed wings while fruit-eating species had broader, less pointed wings. Differences in wing morphology were tested for four insectivorous and two fructivorous species. Over a three week period, 386 bats were captured by hand, butterfly net, and mist net. Five measurements and a wing tracing were taken to calculate aspect ratio and wing loading. ANOVA tests were performed to test the differences in aspect ratio and wing loading between the two groups. Differences in aspect ratio were found to be significant ($p<0.05$). No significant difference was found for wing loading between the two groups. My finding indicate that there exists a difference in wing morphology but continued study related to the aspect ratio is needed.

SAPROLEGNIACEOUS FUNGI PARASITIC IN EGG MASSES AND LARVAE OF MIDGES (CHIRONOMIDAE). Dana Calabrese and W. Wallace Martin, Dept. of Biol., Randolph-Macon Col., Ashland, Va. 23005. A number of saprolegniaceous fungi were isolated from egg masses and young larvae of various chironomid species collected from a local pond. Isolates were obtained in unifungal culture on CMA and YPSS agars and they were subsequently used to inoculate hempseed, adult fly, and larval chironomid substrata. Morphological, cytological, and developmental studies of vegetative, asexual, and sexual stages produced by the fungi on these substrata were carried out. Each isolate was characterized by the shape, dimensions, and developmental patterns of hyphae, appressoria, zoosporangia, zoospore cysts, oogonia, oospores and antheridia. The isolates were found to represent single species of *Leptolegnia*, *Aphanomyces*, and *Saprolegnia*. Preliminary studies indicate that the *Leptolegnia* isolates may represent a new species most closely related to *L. chapmanii* and *L.caudata*. These studies have also revealed that the *Aphanomyces* and the *Saprolegnia* isolates are most closely related to *A. laevis* and *S. diclina*, respectively. All isolates were observed to produce appressoria in both *in vivo* and *in vitro* culture.

AN EVALUATION OF KIN RECOGNITION IN LARVAL FOUR-TOED SALAMANDERS *HEMIDACTYLIUM SCUTATUM* (Caudata: Plethodontidae). Carrie A. Carreno, Tomalei J. Vess*, and Reid N. Harris, Dept of Biology, James Madison Univ., Harrisonburg, VA 22807. Larvae of the four-toed salamander, *Hemidactylium scutatum*, were investigated to determine their ability to recognize and discriminate between related and familar conspecifics. Six aggressive and submissive behaviors were used as measures of recognition. In order to distinguish between kin recognition and familiarity, a two factor design was used yielding four treatments: familiar siblings, unfamiliar siblings, familiar non-siblings, unfamiliar non-siblings. *Hemidactylium* larvae did not show significant kin recognition ability or the ability to recognize conspecifics based on familiarity. These results are consistent with the larval ecology of these organisms.

SMALL MAMMAL POPULATION DYNAMICS AT MT. LAKE BIOLOGICAL STATION. Jack A. Cranford and Deborah S. Fortune, Mt. Lake Biological Station, Biology Dept, Univ. of Virginia, Pembroke, VA. Small mammal population studies and habitat analysis were initiated in 1992 with the establishment of three study grids. In 1993, four additional grids were established and three will be added to the study in 1994. Chipmunk burrow placement and habitat structure were evaluated in 1993 and were significantly associated with dense, complex habitat proximate to large diameter living and dead trees. *Peromyscus* population densities at mid-summer were between 8-14/ha, food supplements added to three areas resulted in breeding initiation three weeks earlier on these grids. Meadow voles reached peak densities of 125/ha. but, in the fall and winter of 1993-1994 meadow vole densities declined to low levels and during this period the area was colonized by bog lemmings. Ice storm damage was extensive and the result of that major habitat change will be evaluated this summer.

THE EFFECTS OF DIETARY NITROGEN ON NITROGEN FIXATION (ACETYLENE REDUCTION) RATES IN RETICULITERMES (ISOPTERA: RHINOTERMITIDAE). Anthony D. Curtis & Deborah A. Waller, Dept. Biol. Sci., Old Dominion University, Norfolk, Va. 23529. Termites are able to fix atmospheric nitrogen (N) by means of their hindgut bacteria. Variation in N fixation rates may be related to food quality. We used the acetylene reduction bioassay to measure nitrogenase activity in Reticulitermes workers in relation to the N content of the host log. Ten Reticulitermes colonies were assayed for nitrogenase activity from July 1993 through January 1994 in a tidal wetland forest in Brownsville, Virginia. N content (% dry biomass) of wood infested by the termites was examined in July, October and January. Log N varied significantly within a collection period, but there was no clear seasonal pattern, and there was no association between log N content and termite nitrogenase activity. Seasonal variation in nitrogenase activity was related to temperature in both laboratory and field experiments, with optimal rates at moderate temperatures and decreased rates at both high and low temperatures.

PREVALENCE AND GEOGRAPHIC DISTRIBUTION OF THE RACCOON NEMATODE, BAYLISASCARIS PROCYONIS. Ralph P. Eckerlin, Natural Sciences Div., Northern VA Comnty. Col., Annandale, VA 22003. Baylisascaris procyonis (Stefanski and Zarnowski, 1951) Sprent, 1968 is a common nematode parasite of the small intestine of raccoons, Procyon lotor, throughout much of the United States. There are few reports from Virginia and those studies suggested that B. procyonis was rare or absent from non-mountainous portions of Virginia. Twentytwo raccoons from northern Virginia, namely from the counties of Arlington, Fairfax, and Fauquier, were examined. Eleven raccoons from Fairfax County and one from Fauquier County were infected with B. procyonis. The prevalence of infection was 55%, range of infection 1-112, and the mean intensity of infection was 23.0. Female worms outnumbered males slightly. A female B. procyonis has been reported to release about 215,000 eggs per day and the eggs persist in the soil for many months. These eggs, when ingested by homeothermic animals, hatch out and cause visceral larva migrans, often with fatal results.

AKINETE DIFFERENTIATION IN ANABAENA. I. STRUCTURAL AND MOLECULAR CHARACTERIZATION. Robert W. Fisher, Peter A. Reavey, and Muralidhar Nannapaneni, Department of Biology, Virginia Commonwealth University, Richmond, Virginia 23284-2012. Akinetes are dormant cells which differentiate in some species of cyanobacteria when growth conditions become stressful. We are characterizing the structural, biochemical, and molecular genetic changes which take place during akinete differentiation. We can induce akinete differentiation in Anabaena by subculturing log phase stock cultures into growth medium lacking phosphate. Log phase cells placed in induction medium have a reduced septation rate, become enlarged, form thicker cell walls, and accumulate numerous cyanophycin granules. Several water soluble proteins can be resolved using SDS-PAGE which appear to be akinete specific. DNA has been isolated from both induced and not induced cell types and is currently being compared using restriction enzyme profiling combined with PCR amplification. (Supported in part by the Grant-in-Aid Program for Faculty at Virginia Commonwealth University)

BURROW USE AND BURROW STRUCTURE OF PEROMYSCUS SPECIES AT MT. LAKE BIOLOGICAL STATION. Deborah S. Fortune and Jack A. Cranford, Mt. Lake Biological Station, Biology Dept, Univ. of Virginia, Pembroke, VA. Burrows were located by visual observation upon animal release and by the string tag method. Visual observation worked through the non-vegetative months and early spring but string tags permitted easy burrow location during all seasons. Burrows were permanently marked and were monitored for activity. Animals utilized ground burrows throughout the year and burrows were classified as multiple or single usage structures. Animal associated with burrows were recorded by species, age, sex and reproductive condition. Twenty burrows of each usage type were fully excavated, mapped and measured. Multiple use burrows had significantly larger entrances, more entrances, larger nest chamber sizes, longer total tunnel lengths, more tunnel direction changes, and more cached food types and volumes, Tunnel entrances were directed away from prevailing weather patterns.

DETERMINING THE OPTIMAL DETERGENT FOR BONE MARROW SOLUBILIZATION. Kevin Gates and Lloyd Wolfinbarger Jr. Center for Biotechnology, Old Dominion University, Norfolk Va. 23529. Human bone allografts are extensively used in a variety of clinical applications. With today's technology, human cadaver bone can be successfully implanted into a patient in order to replace damaged and/or deteriorated bone or to correct a person's posture and alignment. However the bone marrow in bone is immunogenic and can cause an immunological response in the recipient of the allograft tissue. Removal of the bone marrow in the allograft before implantation will reduce the risk of an immune response in the recipient. Bone marrow can be successfully removed by flushing the allograft with a detergent solution. The objective of this experiment was to evaluate which detergent was most effective in solubilizing the cellular material in the bone matrix. Porcine femurs were obtained from Gwaltney Packaging Plant in Smithfield, Va. Bone cores were randomly bored from bisected femur heads, then weighed and placed into test tubes. The weight of the bone cores varied between 0.30 to 0.08 g with an average weight of 0.22 +/- .034 g. Each core was placed into separate test tubes. A constant volume of 10 ml of different concentrations of detergent was added to each test tube. The bone cores were allowed to solubilize for 24 hours and a Lowry protein assay was performed in order to measure the amount of protein solubilized from the cores. The results were inconclusive due to the heterogeneous distribution of bone marrow throughout the femur head. Furthermore, because of a detergent's potential inability to effectively solubilize bone marrow above the critical micellar concentration, it is not feasible to determine the optimal detergent without having the critical micellar concentrations of each detergent. Further research that includes the critical micellar concentration of each detergent will aid in determining the optimal detergent for use in bone marrow solubilization.

FORENSIC TECHNIQUES FOR THE EXAMINATION OF FEATHERS AND PRACTICAL APPLICATIONS. Roxie C. Laybourne[a*] and M. Josephine Babin[b], [a]NHB E 605, MRC 116, National Museum of Natural History, Washington DC 20560; [b]George Washington University Hospital, Wilson Genetics Unit, Ross Hall, Room 455, 2300 I St. NW, Washington DC 20037. Feathers collected in the field can be a source of information about interspecific associations and species presence, as well as a tool for systematic studies. Presented here are basic techniques used for effective identification of feathers: The preparation of the feather material, both pennaceous and plumulaceous, for macroscopic and microscopic examination, the collection of relevant data, and the use of museum specimens for comparison.

A STUDY OF THE EFFECTS OF VARIOUS PH LEVELS ON THREE GENERA OF OLIGOCHAETES: AEOLOSOMA, DERO, AND PRISTINA. Rebecca Halloran, Elsa Q. Falls, and Arthur F. Conway, Department of Biology, Randolph-Macon Col., Ashland, VA 23005. In some previous investigations of water pH changes, certain species from Class Oligochaeta have been identified for potential use as indicator species. In this study, three genera of freshwater oligochaetes, Aeolosoma, Dero, and Pristina,were subjected to a range of pH's to determine effect on mortality and asexual reproduction. The worms were cultured at room temperature in petri dishes of spring water adjusted to the following pH levels: 4.0-4.7, 5.0-5.5, 6.2-7.0, 8.5-9.0, and 9.5-10.0; observations were made once every 24 hours for 72 hours. The three genera survived at all pH levels, although mortality rates were higher the lower the pH. Asexual reproduction by budding was more common at higher pH levels, particularly in Pristina. The data indicate that these three genera should not be considered as good indicator species because of their tolerances to wide variation in pH.

NEW STATE RECORDS AND BIOLOGICAL NOTES ON TURKEY MALLOPHAGANS IN VIRGINIA, AND OBSERVATIONS OF TURKEYS. James M. Hill, Dept. of Biology, Randolph-Macon Col., Ashland, VA 23005 and Ralph P. Eckerlin, Dept. of Biology, Northern Virginia Cmnty. Col., Annandale, VA 22003. Wild turkeys were found to be abundant on the Northern Neck of Virginia in fall 1993- spring 1994, with flock sizes ranging from 15-100 birds. Three turkeys collected in Northumberland Co., VA were inspected for head lice. Three species of chewing lice were found on a sub-adult male, 74 *Chelopistes meleagridis*, 20 *Oxylipeurus p. polytrapezius*, and 14 *O. corpulentus* with the latter two species being new Virginia records. Daily monitoring of study skins disclosed that the subadult male had lice still alive until 17 days after dying. The adult male had no lice. Conservation status and ectoparasites of the Meso-American Ocellated turkey and general future research needs are discussed.

STATUS AND DISTRIBUTION OF THE ALLEGHENY WOODRAT IN VIRGINIA WITH NOTES ON ECOLOGY. James E. Kenney, Michael T. Mengak and Janet Holland, Environmental Science Program, Life Sciences Department, Ferrum College, Ferrum, VA 24088. The Allegheny Woodrat (*Neotoma magister*) has been located in 17 counties in Virginia with 39 active sites (woodrats being present) being reported. Trapping activities began by trapping at a possible site for one night. Yearly monitoring at a involved trapping for two consecutive nights between mid-September to mid-October. Once survey and monitoring sites were established, trapping has been done on a regular basis since June 1990. Sites are checked in late spring and summer each year, with periodic checks in other months. Results of monitoring since September 1990 show a marked decrease in woodrat populations in Virginia with overall catch per effort dropping from 1.2 per 10 trap nights in 1990 to 0.5 per 10 trap nights in 1993. We present data on woodrat population trends, home range and movements, and habitat analysis.

SOCIAL INFLUENCES ON REPRODUCTIVE MATURATION IN FEMALE WHITE-FOOTED MICE (PEROMYSCUS LEUCOPUS NOVEBORACENSIS). Michelle L. Mabry & C. Richard Terman, Lab. of Endocrinology & Population Ecology, Biology Dept., Col. of William & Mary, PO Box 8795, Williamsburg, VA 23187-8795. Studies on the house mouse (*Mus musculus*) have demonstrated that when juvenile females are housed with other juveniles or adult females, reproductive maturation of the juveniles is delayed compared to juveniles housed alone. This delay has further been shown to be caused by a urinary chemosignal produced by the grouped females. Similar procedures were used in this study using juvenile white-footed mice, but no delay in maturation was seen, as evidenced by age of vaginal introitus, first estrus, or reproductive organ masses. These findings will be discussed.

HEMOCYANIN SUBUNIT COMPOSITION IN SIBLING SPECIES OF THE MARSH CRAB SESARMA FROM THE GULF OF MEXICO AND THE NORTH AMERICAN ATLANTIC COASTS. Amanda L. McKenney and Charlotte P. Mangum, Dept. of Biol., Col. of William and Mary, Williamsburg, Va. 23185. The electrophoretic banding patterns of the hemocyanin in the sibling species, Sesarma sp. (nr. reticulatum) and Sesarma reticulatum, were analyzed. In Sesarma sp. (nr. reticulatum) a total of eleven bands were found, with a minimum of five and a maximum of nine in an individual. Seven bands comprised the major fraction of the material. In S. reticulatum a total of nine bands were found, with a minimum of six and a maximum of seven bands in an individual. Six bands comprised the majority of the material. When the banding patterns were examined in adjacent lanes on the same gel, qualitative differences between the two species were clear. Two bands in Sesarma sp. (nr. reticulatum) and one band in S. reticulatum did not co-migrate with a band in the other species. Each species had five bands which were invariant; however, those five bands in one species did not co-migrate with the five invariant bands in the other. In both species the variation of one band was coupled with that of another, in a way that suggests the possibility of alleles.

CYTOTOXIC ACTIVITY OF STIMULATED LYMPHOCYTES AGAINST ME-180 CELLS. Joseph Moorman and Rosemary Barra, Dept. of Biol. Sci., Mary Washington College, Fredericksburg, VA 22401. Stimulating lymphocytes to become specific activated killer cells against cancer cells hold possibilities for future cancer treatments. The stimulation of lymphocytes by incubation with two cytokines, interleukin-2 and interferon gamma, was investigated in this study. Human lymphocytes were collected from a donor and incubated with human recombinant forms of the cytokines. The activated lymphocytes were assayed against the ME 180 cell line in tissue culture. Evidence of cytotoxicity caused by the activated lymphocytes against the ME 180s existed. The extent and potency of the cytotoxic activity of the lymphocytes varied depending upon the cytokines used, quantity of cytokines used, and the combination of cytokines. The results clearly indicate that lymphocytes stimulated by IL-2 and IF-γ show cytotoxic activity toward the ME- 180 cells.

EFFECTS OF PARITY ON THE DISTRIBUTION OF GRANULATED METRIAL GLAND CELLS IN THE PREGNANT MOUSE UTERUS. Josephine B. Owusu-Sakyi, H. Carl Palmer, Jr.*, and Carolyn M. Conway, Dept. of Biology, Va. Commonwealth Univ., Richmond, VA 23284-2012. Large round cells containing numerous glycoprotein granules, referred to as granulated metrial gland (GMG) cells, accumulate in the pregnant uterus of rodents. The periodic acid Schiff technique was used to stain GMG cells in implantation sites (at 12.5 days of gestation) of 8 month old CD-1 mice of different parity classes (1st, 2nd, and 3rd pregnancies). Although GMG cells were located mainly in the decidua basalis, a small number of GMG cells were occasionally found in the placenta, maternal blood spaces, and the myometrium. The distribution of GMG cells within the decidua basalis was determined using morphometric techniques. Very few GMG cells were located in the region of the decidua basalis adjacent to the placenta. The number of GMG cells increased slightly in the mid-region of the decidua basalis. A significant increase in the number of GMG cells occurred in the region of the decidua basalis adjacent to the myometrium. Neither the total number nor the overall distribution of GMG cells in the decidua basalis was affected by parity. (Supported by the Undergraduate Research Grant Program of Va. Commonwealth Univ.)

MOVEMENT PATTERNS OF COPPERHEAD SNAKES IN SOUTHEASTERN VIRGINIA. Christopher E. Petersen, Dept. of Biol. Sciences, Old Dominion Univ., Norfolk, Va. 23529-0266. Radiotelemetry was used to study the seasonal movement patterns of five copperhead snakes (*Agkistrodon contortrix*) in southeastern Virginia. Movements were summarized by distance, direction, and time elapsed since last location. The data suggest that movements reflect availability of prey. Copperheads spent considerable time moving between cane (*Arundinaria*) patches and river swamps, where densities of potential prey species have been demonstrated to be high. Evidence also suggests that males may engage in long movements more frequently and have larger activity ranges than do females.

BIOLOGICAL ANALYSIS OF WATER QUALITY OF THE OPEQUON CREEK. Anne M. Powers, Christopher Lee, Allen J. Whitehead, Nicole Wilkes, Ronda Howard*, Division of Natural Sciences and Mathematics, Shenandoah University, Winchester, VA 22601. The Opequon Creek, part of the Potomac Watershed, traverses several counties in West Virginia and Virginia including our test sites in Frederick and Clarke Counties, VA. Analysis of preliminary data demonstrated significant levels of fecal coliforms in the Opequon Creek. Mile thirty-seven was chosen from a series of sights surveyed for this study. Multiple monthly samples from December through April were taken and analyzed. Fecal coliform counts ranged from 300 to 1400 cells/100ml using MPN tables. These were levels far above those allowed for recreational use. The Pollution Tolerance Index of Benthic macroinvertebrates showed a prevalence of group one taxa demonstrating good water quality. The dissolved oxygen ranged from 12-14 mg/L supporting the macroinvertebrate growth. Excessive silt deposits were noted and thought to be related to stream bank erosion. The pH of the water was always in the range of 6.8-7.8. Integrating data from these studies indicated a stream of good water quality. However, the erosion, silt, and the fecal coliform counts were indicative of non-point pollution sources. Continued study of the Opequon Creek is needed.

MOVEMENT PATTERNS OF COPPERHEAD SNAKES IN SOUTHEASTERN VIRGINIA. Christopher E. Petersen, Dept. of Biol. Sciences, Old Dominion Univ., Norfolk, Va. 23529-0266. Radiotelemetry was used to study the seasonal movement patterns of five copperhead snakes (*Agkistrodon contortrix*) in southeastern Virginia. Movements were summarized by distance, direction, and time elapsed since last location. The data suggest that movements reflect availability of prey. Copperheads spent considerable time moving between cane (*Arundinaria*) patches and river swamps, where densities of potential prey species have been demonstrated to be high. Evidence also suggests that males may engage in long movements more frequently and have larger activity ranges than do females.

EFFECT OF MATERNAL AGE ON INDUCTION OF RESORPTION BY INTRAPERITONEAL INJECTION OF LIPOPOLYSACCHARIDE IN CD-1 MICE. R. M. Reale, P. S. Nyantakyi, and A. F. Conway, Dept. of Biol., Randolph-Macon Col., and C. M. Conway, Dept. of Biol., Va. Commonwealth U. Three possible mechanisms for increased frequency of pregnancy loss in older female mammals were evaluated by comparing lipopolysaccharide (LPS) stimulated and control females at ages of three, nine to ten, and twelve months. Pregnant CD-1 mice were injected intraperitoneally with 1 ug of LPS on day 9 and sacrificed on day 12 of gestation. Treatment with LPS had no effect on spleen weight or dorsal lymph node weight, indicating that LPS acted primarily through paraimmune rather than specific immune mechanisms. Treatment with LPS significantly reduced maternal weight gain between treatment and sacrifice and reproductive tract weight. Increased maternal age reduced maternal weight gain and significantly reduced reproductive tract weight. Maternal age caused no change in frequency of resorption (pregnancy loss) in control animals. Treatment with LPS significantly increased frequency of resorption and the increase was larger in older females. These results are inconsistent with pregnancy loss mechanisms involving loss of uterine sufficiency or loss of immunotrophism with increased age, but are consistent with mechanisms involving selective loss of immunosuppression with increasing maternal age.

EVALUATION OF THE GROSS ANATOMY AND SEASONAL CHANGES IN A PERINEAL GLAND IN THE HISPID COTTON RAT, SIGMODON HISPIDUS. Robert K. Rose and Julie Winchell, Dept. of Biological Sciences, Old Dominion University, Norfolk, VA 23529-0266. A perineal gland is described for the hispid cotton rat, Sigmodon hispidus. Seasonally cyclical in association with the reproductive organs of males, the gland possesses a strong attachment to the penis, with only loose fascial connections to the rectum and surrounding tissues. Its seasonal growth and regression closely parallel that of the testes and seminal vesicles, indicating that this cyclicity may be under androgen control. Significant differences in the weights of perineal glands, testes and seminal vesicles were noted between the breeding and non-breeding seasons when using a general linear model analysis of variance (ANOVA). The weight of the gland also showed highly significant correlations to the weights of testes and of seminal vesicles. Further evaluations, using ANOVA with stepwise regression, indicate the close association of these three organs, the predictive model for which is: perineal gland weight = -18.67 + 0.443 (testes weight) + 0.398 seminal vesicles weight).

DISTRIBUTION OF LIPOPOLYSACCHARIDE-COATED LATEX MICROSPHERES IN PREGNANT CD-1 MICE FOLLOWING INTRAVENOUS INJECTION. S. S. Soza, J. C. Burnett, and A. E. Conway, Dept. of Biol., Randolph-Macon Col., and C. M. Conway, Dept. of Biol., Va. Commonwealth U. Distribution of lipopolysaccharide (LPS) in pregnant CD-1 mice was studied using LPS-coated fluorescent latex microspheres (1 um diameter). Controls included uncoated and glucose-coated microspheres. Mice were injected in the right lateral tail vein on day 9 of gestation and sacrificed 6, 12, or 24 hours later. Distributions were studied by fluorescent microscopy of frozen sections. Both LPS-coated and control microspheres accumulated in the maternal spleen and liver. Increased (relative to controls) accumulation of LPS-coated microspheres was observed in the maternal dorsal lymph nodes, below the myometrium in uterine decidual tissue, and near the maternal-embryonic interface. These results are consistent with LPS causing loss of implanted embryos either through direct action on the maternal-embryonic exchange surfaces or through triggering inflammatory changes in adjacent maternal tissues.

PLANT CHEMISTRY AND MULTIPLE TROPHIC LEVEL INTERACTIONS: INFLUENCE OF SINIGRIN ON *PIERIS RAPAE* (LEPIDOPTERA: PIERIDAE) AND ITS PARASITOID, *COTESIA RUBECULA* (HYMENOPTERA: BRACONIDAE). Eric Summer & D. Karowe*, Dept. of Biol., Va. Commonwealth Univ., Richmond, Va. 23284. All plants contain secondary compounds. Much research has addressed toxic or deterrent chemicals that apparently exist solely in order to defend the plant against herbivores. However, little is known about the effects of plant secondary compounds on higher trophic levels (e.g. parasitoids), though higher trophic levels also are routinely exposed to these chemicals. If secondary compounds adversely affect parasitoids, plants may face an evolutionary dilemma: increasing their intrinsic defense through production of secondary compounds may decrease their extrinsic defense by harming predators and parasitoids. This study examined the effects of sinigrin, a common secondary compound of crucifers, on the fitness of *Cotesia rubecula*, a specialist parasitoid wasp of crucifer herbivores, including *Pieris rapae*. *C. rubecula* were reared in *P. rapae* fed on artificial diet containing 0, 250, 500, 1000, or 1500 mM sinigrin, which spans the range of values reported from crucifer leaves. ANOVA revealed that neither parasitoid pupal weight, development time, nor growth rate was significantly affected by sinigrin concentration. This result suggests that the presence of sinigrin in crucifers does not compromise extrinsic defense afforded by *C. rubecula*. It is possible that specialist parasitoids may in general be less affected than generalist parasitoids by plant secondary compounds.

REPRODUCTIVE RECOVERY OF WILD WHITE-FOOTED MICE IN THE LABORATORY. C. Richard Terman, Lab. Endo. & Pop. Ecology, Dept. Biol., College of William and Mary, Williamsburg, VA. 23185. Reproduction is consistently curtailed during May, June, and July in a wild population of *Peromyscus leucopus noveboracensis* which has been studied since 1983 (Terman, 1993, J. Mamm., 74:678-687). Wild mice were captured during the period of reproductive hiatus and at other times of the year and paired for 100 days in the laboratory with each other or with parous or nulliparous laboratory animals. Reproduction following pairing with laboratory mates was significantly more frequent ($P \leq .01$) and of shorter latency for wild males than for wild females no matter when captured. Wild pairs rarely reproduced until re-paired with laboratory mates following which wild males reproduced significantly more frequently than wild females ($P \leq .01$). Reproductive performance did not differ between animals captured during the breeding hiatus and during other times of the year (Supported by a College of William and Mary Faculty Summer Research Grant and by the Thomas F. and Kate Miller Jeffress Memorial Trust).

IS "CARRYING CAPACITY" AN ECOLOGICAL MISNOMER? BEHAVIORAL CONSIDERATIONS. C. Richard Terman, Lab. Endo. & Pop. Ecol., Biol. Dept., College of William and Mary, Williamsburg, VA 23185. The concept of "Carrying Capacity" is of wide usage both in the applied and theoretical population ecology literature. Examination of this literature reveals considerable variability in definition of the concept. Derived from the application of the logistic equation to questions of population control or equilibrium, "K" is often regarded as reflective of the Carrying Capacity of the environment. Experimental studies, both laboratory and field, demonstrate that population numerical levels may be quite variable when asymptote or equilibrium is attained under similar conditions of the physical environment. Theoretically, only the largest population is at carrying capacity while the growth of other populations appears to be curtailed below this carrying capacity. Such differences in equilibrium levels of populations appear to reflect intrinsic differences in populations. Behavioral implications will be discussed.

EFFECT OF PRENATAL EXPOSURE TO LEVONORGESTREL OR TO ETHENYL ESTRADIOL AND NORETHINDRONE ON EXTERNAL GENITAL AND TESTIS DEVELOPMENT IN CD-1 MICE. H. S. Thompson and A. F. Conway, Dept. of Biol., Randolph-Macon Col. Pregnant CD-1 mice were subcutaneously injected with 0.05 ug/day of levonorgestrel (LN) in corn oil or with 0.018 ug/day of ethynyl estradiol plus 0.25 ug/day of norethindrone (EEN) in corn oil to mimic the results of Norplant or oral contraceptive use in humans. Controls were injected with corn oil. Injections began on day 8 of gestation and continued daily until sacrifice on day 18. At sacrifice, all fetuses were measured and sexed. Gonads of male fetuses were embedded, sectioned, and analyzed microscopically for area fractions of each component. Neither treatment affected crown-rump length, but both treatments resulted in shorter anogenital distances in fetuses of both sexes (statistically significant in LN-treated female fetuses). Treatment with LN had no effect on area fraction of any component measured in fetal testes. Treatment with EEN increased area fractions of non-lipid filled Leydig cells with the increase becoming marginally statistically significant in the seminiferous tubule-packed peripheral regions of the testes.

SEX AND AGE CLASS HABITAT DISCRIMINATION BY *Peromyscus* spp. AT DIFFERENT STAGES OF GYPSY MOTH DISTURBANCE. David C. Tomblin and Jack A. Cranford, Biology Department and Museum of Natural History, VPI & SU, Blacksburg, VA, 24061. Demographic structure and microhabitat use among sex and age classes of *Peromyscus* spp. were evaluated at four oak dominated sites impacted by gypsy moths; high tree mortality, disturbance in process, disturbance recovery, and a undisturbed site. *P. leucopus* populations at the disturbed sites exhibited greater demographic stability than reference site populations. There was evidence for density-dependent population regulation at the high mortality and recovery sites. At high densities, *P. leucopus* populations at the high mortality site and the *P. maniculatus* population at the recovery site exhibited intraspecific microhabitat segregation. Female adults segregated from male adults and juveniles and male adults segregated from male juveniles into more optimal microhabitats. The results of this study suggest that gypsy moth at least temporarily improve quality of habitats previously dominated by chestnuts oaks.

COMPARISON OF TUMOR NECROSIS FACTOR-ALPHA CONCENTRATIONS IN PERI-EMBRYONIC TISSUES OF NORMAL AND RESORBING IMPLANTATION SITES IN CD-1 MICE. C. P. Toomey and A. F. Conway, Dept. of Biol., Randolph-Macon Col., and C. M. Conway, Dept. of Biol., Va. Commonwealth U. The hypothesis that resorption (pregnancy loss) results from excessive concentrations of tumor necrosis factor-alpha (TNF-alpha) around implanted embryos was evaluated by comparison of samples from pregnant CD-1 mice in which resorption had been induced by intravenous injection of lipopolysaccharide (LPS) 15 hours before sacrifice with control samples. Organ samples were cut from frozen sections and analyzed by ELISA. Treatment with LPS did not significantly elevate TNF-alpha concentrations in maternal serum, spleen, or liver. Preliminary results indicate that LPS treatment elevated TNF-alpha concentrations near the uterine myometrium and reduced concentrations in the placenta and around the body of the embryo, but none of these differences were statistically significant. These results are inconsistent with hypotheses involving large increases in TNF-alpha concentrations at the maternal-embryonic interface during pregnancy loss.

THE AVAILABILITY OF SMALL MAMMAL PREY FOR FORAGING PIT VIPERS. Victor R. Townsend Jr., Col. of Sciences, Dept. of Biol., Old Dominion Univ., Norfolk, Va 23529-0266. The Canebrake Rattlesnake (*Crotalus horridus atricaudatus*) and the Northern Copperhead (*Agkistrodon contortrix*) are forest-dwelling pit vipers which, as adults, feed predominantly upon small mammals. The frequency of predation by viperid snakes usually reflects the relative abundance of prey species in the environment. From October 1993 through March 1994 I studied the availability of small mammal prey for foraging pit vipers in a variety of microhabitats in southeastern Virginia. In addition, observations of snake activity were used to construct an energy budget for these species of pit vipers, in an attempt to estimate prey requirements and the effect of diet on such variables as reproductive effort and hibernation. Together with the data on prey availability, the energy budget can be used to interpret seasonal foraging activity and microhabitat use by the snakes.

NUMBERS OF FLAGELLATE PROTOZOANS IN RETICULITERMES (ISOPTERA: RHINOTERMITIDAE) HINDGUTS RELATED TO SEASON AND TERMITE SIZE. Deborah A. Waller, Dept. Biol. Sci., Old Dominion Univ., Norfolk, Va. 23529. Termites of the genus Reticulitermes harbor hindgut protozoans that catabolize the cellulosic foods they ingest. Little is known about seasonal patterns in protozoan numbers because the subterranean termite hosts generally overwinter deep underground. However, Reticulitermes colonies spend winter in surface logs in a tidal wetland forest in Brownsville, Virginia. The protozoan populations in worker hindguts were examined monthly for ten termite colonies. Protozoans persisted in low numbers during winter months when termites survived log temperatures as low as 2.1°C. Larger termites harbored greater numbers of protozoans. Protozoan populations increased with warmer temperatures in spring, especially those of the flagellate Trichonympha, which has been previously demonstrated to respond to the nutritional status of the termite host.

Biomedical and General Engineering

THE SOPA SURFACES. William P. Harrison, Jr., Engr. Fundamentals Div., Va. Polytechnic Inst. & State Univ., Blacksburg, VA 24061. The principal angles Θ_F, Θ_H, and Θ_P of a plane in space are defined as angles between the plane and the frontal, horizontal, and profile planes of projection. The sum of these angles, $\Sigma\Theta$, must be equal to or less than 180° for all positions of the plane in space. This leads to an investigation of those surfaces that represent this sum of the principal angles (SOPA), the so-called SOPA surfaces. The independent variables introduced are the rotational angles Θ_V and Θ_L, where Θ_V measures rotation about a vertical axis and Θ_L measures rotation about a horizontal (latitudinal) axis perpendicular to the profile plane of projection. The magnitudes of Θ_V and Θ_L, as well as the order in which they are performed, both determine $\Sigma\Theta$, since they are not commutative in rotation. Thus, two SOPA surfaces emerge as descriptive of $\Sigma\Theta$ for all values of the independent variables Θ_V and Θ_L. In this paper the defining equations are developed, and interesting characteristics of these SOPA surfaces, such as boundaries, minimums, and symmetry, are discussed and shown.

A NEURAL NETWORK BASED ACOUSTIC FETAL HEARTRATE MONITOR. David L. Livingston, Div. Engr. & Ind. Tech., Va. Western Cmnty. Col., Roanoke, Va. 24038, & Stephen A. Zahorian & Roger Zhao*, Dept. of Elec. & Comp. Engr., Old Dominion Univ., Norfolk, Va. 23529. Fetal heartrate has traditionally been measured using the trained ear of a professional with the assistance of an acoustic amplifier or measured automatically using active ultrasonic devices. We report on the development of a system which uses neural networks in conjunction with advanced acoustic sensors and signal processing techniques to extract fetal heartrate from a noisy environment without subjecting the fetus to machine generated energy. The acoustic fetal heartbeat signal is transduced by a belt consisting of an array of acoustic sensors. The resulting signal is electronically amplified and filtered as preprocessing for a neural network. A feedforward neural network trained with back-propagation detects the presence of a fetal heartbeat within the noisy in-vivo environment and produces a signal marking each beat. Autocorrelation techniques are used on the signal produced by the network to extract the heart rate. Provisions are made for detecting loss of signal and automatic sensor selection to acquire the strongest signal. The resulting heartrate information is displayed and stored on a portable computer and may be used in real time or analyzed at a later date. The ultimate goal of the system is the ability to use it as a portable device in non-clinical situations such as home use in high-risk pregnancies. (Supported by NASA Langley Research Center, Hampton, Va.)

Botany

SUCCESSIONAL CHANGES FOLLOWING A MAJOR LANDSLIDE IN ALLEGHANY COUNTY, VIRGINIA. H. S. Adams, D. S. Lancaster Cmnty. Col., Clifton Forge, VA 24422 and E. G. Haverlack*, USDA For. Serv., Covington, VA 24426. On April 17, 1987, following a period of several days of heavy rains, a landslide occurred on a west-facing slope in Rainbow Gap along the Jackson River in Alleghany County, Virginia. The site is clearly visible from U.S. Route 220 between Clifton Forge and Iron Gate. Maximum relief of the slide is around 152 m, extending from the river (305 m) up a very steep slope ($\geq$75% inclination) to 457 m (slightly more than halfway to the ridge). Width is approximately 100 m. Forest composition to either side of the slide is predominantly ***Quercus rubra*** (red oak), ***Q. prinus*** (chestnut oak), and ***Pinus virginiana*** (Virginia pine). In September, 1988 and 1993, we obtained data to describe the general vegetation coverage in the slide region. Since the original slide (which removed all vegetation and topsoil), both number of taxa (59 recorded in 1988 and 103 in 1993) and total coverage (now approximately 50% from original bare substrate) have increased substantially. The greatest increase in number of taxa occurred among non-woody plants (96%). Not surprisingly, plant successsion within the slide area is proceeding from the margin of the adjacent forest with least plant encroachment occurring near the top. Plants having wind-distributed seeds are responsible for the majority of recolonization of the slide. ***Paulownia tomentosa*** (princess tree) and ***Robinia pseudoacacia*** (black locust) are two examples of early successional woody species invading the slide area.

A NEW ARBORETUM FOR THE STATE OF VIRGINIA. Invited Paper. Norlyn L. Bodkin, Director, JMU Arboretum, JMU, Harrisonburg, VA. 22807. A new arboretum is being developed on the campus of James Madison University. The 125 acre complex is being established on the slopes of an Oak-Hickory Forest Association and provides an ideal combination of developed gardens and a natural forest each complementing the other and serving the purposes of teaching, research and demonstration. Native plant species are being emphasized. One of the more unique gardens is a shale barren with endemic species. The arboretum is on University property but is not state supported. It is funded through contributions to the JMU Foundation.

ABIOTIC STRESSORS IN THE DOGWOOD ANTHRACNOSE COMPLEX. I. EFFECTS OF TEMPERATURE ON THE GROWTH AND SURVIVAL OF *DISCULA DESTRUCTIVA*. J. B. Crozier and R. J. Stipes, Dept. of Plant Pathol., Physiol., and Weed Sci., VA Tech, Blacksburg VA 24061 Cardinal growth temperatures and response to thermal stress regimes were determined for isolates of *Discula destructiva*, causal agent of dogwood anthracnose. The optimum temperature was between 20 and 22 C, with 4 of 6 isolates growing best at 20 C. All isolates grew within 7 d at 1 C and 28 C, but no growth was noted after 7 d at 30 C, although regrowth occurred after transfer to a lower temperature. All isolates were killed after 7 d at 35 C. The fungus was alive in 88% of 4-mm mycelium agar discs after 5 min at 45 C in water, while it was alive in 51% after 10 min, and in 0% after 15 min. The fungus was alive in 89% of 4-mm discs from autoclaved dogwood leaves on amended PDA, on which *D. destructiva* was allowed to grow, after 10 min at 45 C. The thermal death point of conidia in free water was 46-47 C, and the thermal death times for 45 and 55 C were 20 min and 30 s, respectively, for conidia from oatmeal agar plates. Conidia from autoclaved dogwood leaves on amended PDA were killed within 5 min at 45 C. This information may lead to an understanding of possible climatic barriers, and the thermal treatment of plant material.

ABIOTIC STRESSORS IN THE DOGWOOD ANTHRACNOSE COMPLEX. II. EFFECTS OF ACIDIC FOG ON LEAF SURFACE ANATOMY OF *CORNUS FLORIDA* AND *CORNUS KOUSA* SEEDLINGS. J. B. Crozier, R. J. Stipes, and K. T. Thornham, Dept. of Plant Pathol., Physiol. and Weed Sci., VA Tech, Blacksburg VA 24061. Acidic precipitation reportedly enhances disease severity of dogwood anthracnose (DA) caused by *Discula destructiva* on *Cornus florida*, the flowering dogwood. Seedlings of *C. florida* and *C. Sousa*, the Chinese dogwood which is moderately resistant to dogwood anthracnose, were subjected to acidic fog episodes at pHs 2.5, 3.5, 4.5, and 5.5, using a simulated acidic rain solution. Leaf discs from these and non-treated plants were examined by scanning electron microscopy (SEM). Damage was noted at all pH levels and was primarily confined to the trichomes and stomata. Trichomes appeared dehydrated on both *C. florida* and *C. kousa* leaves, while the "lips" of *C. florida* stomata were increasingly eroded by decreasing pH; *Cornus kousa* stomata were relatively unharmed. At pH 2.5, trichomes of both species seemed to be brittle and fractured, causing deep holes in the lamina. *Discula destructiva* conidia may germinate at trichome bases where damage may cause the leaching of nutrients. Also, the difference in stomatal damage may account, in part, for differences in disease susceptibility.

PHYTOPLANKTON ABUNDANCE IN THE LOWER CHESAPEAKE BAY: I. METHODOLOGY. Barbara Hiller, D. Seaborn, M. Weinstein, & H.G. Marshall, Dept. Biological Sci., Old Dominion Univ., Norfolk, Va. 23529-0266. This is review to identify the standard activities and methodology associated with Chesapeake Bay Phytoplankton Monitoring Program. The program was initiated in 1985 and is sponsored by the Virginia Department of Environmental Quality. Seven stations in the lower Chesapeake Bay are monitored monthly for the composition and abundance of phytoplankton and autotrophic picoplankton above and below the pycnocline, plus productivity and water quality measurements. Field and laboratory protocols are identified, with quality control/quality assurance standards that are followed also given. In addition to the numerous results and conclusions gained from the study, the data is being used to identify trends related to the health of the Bay and provide information for Bay management.

FOREST COMMUNITIES OF THE CENTRAL APPALACHIANS. David M. Lawrence, Dept. of Environmental Sciences, Univ. of Va., Charlottesville, VA 22903, Harold S. Adams, Div. of Arts & Sciences, Dabney S. Lancaster Cmnty. Col., Clifton Forge, VA 24422, and Steven L. Stephenson, Dept. of Biology, Fairmont State Col., Fairmont, WV 26554. Biogeographic patterns in upland forest community composition in the mid-Appalachians were examined using quantitative data on the composition of the overstory (stems $\geq$10 cm DBH) from 216 stands. Sampled stands occupied a wide range of site conditions and included representatives of all of the major forest types present in the region. Preliminary results obtained using TWINSPAN and DECORANA indicate that there are two major forest types: those with a significant component of red spruce and other species typically associated with spruce, and those without a significant spruce component. Red spruce stands can be further differentiated on the basis of codominant species such as balsam fir, Fraser fir, and eastern hemlock. Forest types without a significant spruce component include pitch pine/black oak, scarlet oak, mixed oak, chestnut oak, chestnut oak/black oak, chestnut oak/red maple, red oak/white oak, chestnut oak/red oak, red oak, red oak/red maple, red oak/white oak/black birch, sugar maple/hickory, sugar maple, and hemlock/yellow poplar. The influences of a variety of environmental factors account for the differences that exist in forest community composition, with those factors related to elevation, topographic position, underlying geological substrate, and disturbance history the most important.

DENDROECOLOGY OF THREE RED SPRUCE POPULATIONS ON SALT POND MOUNTAIN IN GILES COUNTY, VIRGINIA David M. Lawrence. Dept. of Environmental Sciences, Univ. of Va., Charlottesville, VA 22903, Harold S. Adams, Div. of Arts and Sciences, Dabney S. Lancaster Cmnty. Col., Clifton Forge, VA 24422, Steven L. Stephenson, Dept. of Biology, Fairmont State Col., Fairmont, WV 26554, Tarek A. Hijaz, Dept. of Environmental Sciences, Univ. of Va., Charlottesville, VA 22903, Charles W. Lafon, Dept. of Geography, Univ. of Tennessee, Knoxville, TN 37996, Neil A. Pederson, School of Forestry, Auburn Univ., AL 36849, Margot C. Wilkinson, Dept. of Environmental Sciences, Univ. of Virginia, Charlottesville, VA 22903, and P. Joy Young, Savannah River Ecology Lab., Univ. of Georgia, Aiken, SC 29803. The primary objective of the present study was to construct and then to compare tree-ring chronologies for three spruce populations (Little Spruce Bog, War Spur, and Mann's Bog) in the Mountain Lake area of southwestern Virginia. A secondary objective was to collect data on community composition, spruce age structure, and spruce growth characteristics at the three sites. The spruce populations at the three sites represent three distinctive age groupings, ranging from an average of 61 rings (breast height) at Mann's Bog to 195 rings at War Spur. Chronologies for the three sites for the period of 1940 to 1992 were generally similar, but correlation (response function analysis) of growth with climatic factors (monthly mean temperature and total precipitation for June of the prior year through August of the year of ring formation) was unique for each site.

HERBACEOUS PLANTS OF THE DYKE MARSH RIVERINE TIDAL EMERGENT WETLAND. Dean A. Lindholm, 14226 Glenkirk Rd., Nokesville, VA 22123 (w/ George Mason Univ.). June 15 - July 15, 1992 survey sampled 53 quadrats of 1 sq.m. herbaceous marsh, quadrats established by 1991 GMU plant inventory. The Shannon-Wiener diversity index was $H'=1.668$ (n=53), and Simpson's diversity index was $C=0.251$ (n=53). Species density, cover, and frequency surveys found that 8 of the 20 sp. encountered made up greater than 98% of each category. *Peltandra virginica* was the most common, present in 98% of the quadrats; *Impatiens capensis* exhibited the greatest density, covering 41.2% of the area sampled; *P. virginica* covered 29.9% of the area sampled. Deepwater elevation surveys of 22 sp. discovered elevation minimums for these sp., including *Nuphar luteum* and *Fraxinus pennsylvanica* as the only sp. growing below mean low tide, the latter probably important in Dyke marsh soil stabilization. *Scirpus fluviatilus*, listed "S1" in Virginia, was common in the sampled marsh, present in 13% of the 53 quadrats and constituting just over 1% of the plants sampled.

THE JUDD GARDEN - AN HISTORIC LEGACY IN THE SHENANDOAH NATIONAL PARK. Peter M. Mazzeo, U.S. National Arboretum, Washington, DC 20002. In March of 1926 a group of concerned citizens met on the porch of Sentinel Lodge, the summer residence of the George H. Judd family, which overlooked the Judd garden and Stony Man Mountain. It was their hope that a large section of the Blue Ridge Mountains of northern Virginia might be designated to become a new national park. Although the cabin and most of the original landscape plantings are long gone, some of the original plant materials, rock walls and other physical artifacts still remain at the site. Because of the historical significance of this four-plus acre site, efforts are now underway to preserve, interpret and ultimately restore the George H. Judd garden area at Skyland, the heart of the Shenandoah National Park, Virginia, that was dedicated on 3 July 1936. A review of the garden history and landscape plant materials is presented.

RICE (*Oryza sativa* L) β-GLUCOSIDASE: PARTIAL PURIFICATION, CHARACTERIZATION AND HISTOCHEMICAL LOCALIZATION. C. Muslim and A. Esen, Dept of Biol., Va. Polytechnic Ins. & State University, Blacksburg, VA 24061. We partially purified rice β-glucosidase from the root and shoot of 5-6 day-old seedlings using a combination of differential solubility and ion exchange chromatography. The partially purified enzyme was characterized with respect to its kinetic properties, substrate specificity, pH optimum, pI, and molecular mass at native and denatured stage. In order to localize the enzyme by histochemical procedures, we applied chromogenic substrates for β-glucosidase to tissue sections, isolated protoplasts and plastids of the seedling shoots. We found that the enzymes have three different peaks of activity toward para-nitrophenyl β-D-glucopyranoside (pNPG). However, activity levels observed on the SDS PAGE using 6-bromonaphtyl β-D-glucopyranoside (6BNG) and Fast Blue R dye were different from those expected on the basis of spectrophotometric assays using pNPG. One of the enzyme has the highest enzyme efficiency (Vm/Km) toward paranitrophenyl β-D-fucopyranoside and pNPG, among the substrates tested. The pH optimum was 4.8-5.0, while one of the enzymes has high pI (estimated 9.6). We estimated that the enzyme has a subunit molecular mass of 60 kD. The enzyme is localized histochemically to the plastid.

ESTIMATION OF PRODUCTIVITY AT SEVEN STATIONS LOCATED IN THE LOWER CHESAPEAKE BAY. Kneeland K. Nesius, Harold G. Marshall, Dept. of Biological Sciences, Old Dominion University, Norfolk, VA 23529-0266. Productivity patterns at seven stations located in the lower Chesapeake Bay over a five year period were seasonal consisting of three major peaks - spring, summer, fall. These variations correlated with seasonal changes of neritic phytoplankters. Stations located near the mouth of the Chesapeake Bay had the lower productivity rates. Annual production rates were higher at the western Bay stations. Average annual production rates over the five year period varied from 300 g $C/m^2/yr$ to 180 g $C/m^2/yr$.

IN VITRO GERMINATION OF *BRASSICA RAPA* POLLEN. Mark A. Newsome and Michael H. Renfroe, Dept. of Biol., James Madison Univ., Harrisonburg, VA 22807. To bettter understand pollen growth and development, chemical constituents that initiate pollen tube development were investigated in *Brassica rapa*. The *Brassica* genus is economically and agronomically important. Determination of a successful in vitro pollen germination medium may provide insights to the in vivo requirements for successful pollination. Many successful in vitro germination media have been reported for binucleated pollen species. However, in vitro germination of trinucleated pollen, such as is found in *Brassica*, has been less successful and few germination media have been reported. Various media and in vitro physical and chemical effects were tested for possible influence on pollen germination . A comparison of carbohydrates in the media revealed that sucrose rather than raffinose or glucose was most effective for germination. Specifically, 20% sucrose provided the highest percentage germination. An initial pH value of 7.4 was determined to be optimal. Density of the pollen population appeared to have an effect. Percentage germination was observed over time with the optimized medium. Effective pollen germination occurred within an hour of incubation in the medium.

PHYTOPLANKTON ABUNDANCE IN THE LOWER CHESAPEAKE BAY: II. MEAN CONCENTRATIONS 1985-1991. Sandra Olek, Mollie Weinstein, David Seaborn, H.G. Marshall, Dept. Biological Sci., Old Dominion Univ., Norfolk, VA 23529-0266. Results of a 6 year data set for the phytoplankton populations in the lower Chesapeake Bay indicate the mean monthly averages over this period. Greatest phytoplankton abundance and biomass was associated with the western Bay stations during spring, summer and fall. These populations were dominated by a diatom flora, with the mean number of total phytoplankton taxa recorded per month as 43. Monthly cell abundance maxima at each station were approximately one order of magnitude greater than the mean concentrations. (Supported by the Virginia Dept. of Environmental Quality).

FLORAL WHORL ONTOGENY IN *BRASSICA RAPA*. Michael H. Renfroe, Dept. of Biology, James Madison University, Harrisonburg, VA 22807. The sequence and pattern of floral organ initiation and development was examined for the rapid-cycling brassica variety of *Brassica rapa*. The order of floral whorl initiation was calyx, followed by androecium and gynoecium, with the corolla forming last. Organs developed for the most part in paired formations. The two carpels developed as a fused pair. The six stamens of the androecium were formed as a set of four followed by the differentiation of a second set of two. Petals differentiated to either side of the final pair of stamens, resulting in a corolla consisting of four petals. The timing and pattern of organ initiation may be related to spatial constraints of the floral meristem.

ANNUAL PHYTOPLANKTON DYNAMICS IN THE PAGAN RIVER, VIRGINIA. David Seaborn & H.G. Marshall. Dept. Biological Sci., Old Dominion Univ., Norfolk, Va. 23529-0266. The Pagan River is a nutrient enriched river system with annual mean levels of total nitrogen and phosphorus at 1.8 and 0.8 mg/l respectively. Three phytoplankton maxima occurred during the year with the highest in fall, followed by summer and spring peaks. Diatom populations were dominant throughout the year at concentrations of 10^7 to 10^8 cells/l. Other populations exhibited distinct periods of greater abundance, and time of development. An upstream station contained the greatest abundance of flora throughout the sampling period. Turbidity levels were high the entire year with an annual secchi reading mean of 0.4 m. When compared to the James River, the Pagan River had greater cell abundance, higher nutrients, and lower secchi depths.

THE VIRGINIA PITCHER PLANT BOGS, PART TWO: NOTEWORTHY BOGS OF DINWIDDIE COUNTY. Philip M. Sheridan, Dept. of Biol., Va. Commonwealth Univ., Richmond, Va. 23284. Dinwiddie County is located along the Appomattox River in southern Virginia west of the town of Petersburg. The fall line divides the piedmont and coastal plain formations in the eastern third of the county and this is where pitcher plant seepage wetlands containing Sarracenia flava L. and S. Purpurea L. occur. Historical stations occurred along Arthur Swamp (Blaha Bog), Hatcher Run (Burgess station), Rohoic (Old Town) Creek and Rowanty Creek. The Arthur Swamp site represented the southern station for the New Jersey Rush, Juncus caesariensis Coville. Over the past ten years new pitcher plant bogs have been discovered on headwaters of Arthur Swamp (Shands Bog), Hatcher Run (Depot Road Bog) and northeast of the town of Addison. All sites are characterized by moderate relief (1-2% slope) and sand-peat saturated soils. There are minor floristic differences between sites. Addison Bog represents the northern most pond pine Pinus serotina Michx. pitcher plant pocosin supporting both Sarracenia species while Shands Bog contains the greatest number of bog rarities.

GENETICS OF ABERRANT SARRACENIA LEAF AND FLOWER COLOR. Philip M. Sheridan, Dept. of Biol., Va. Commonwealth Univ., Richmond, Va, 23284. Sarracenia is a genus of insectivorous plants confined to wetlands of the U.S. and Canada. Eight species are generally recognized with flower and leaf color ranging from yellow to red. Fertile hybrids occur in the wild under disturbed conditions and can be artificially produced in the greenhouse. Thus barriers between species are weak. Normally when crosses occur or are induced between species or between different color types the progeny exhibit a blending of parental phenotypes called incomplete or partial dominance. In most species all-green mutants have been found which lack any red pigment in leaves, flowers or growth point. Self pollinated all-green plants result in all-green offspring and self pollinated wild-type red plants result in red offspring. When all-green plants and wild-type red plants are crossed in these species the offspring are all red plants. These results suggest that red is dominant to the recessive all-green mutant. Since partial dominance is the usual genetic pattern in the genus, dominant/recessive characteristics are an unusual phenomenon.

SYSTEMATICS OF CHAMAESYCE SUBSECTION PLEIADENIAE (EUPHORBIACEAE). Mark P. Simmons and W. John Hayden, Dept. of Biol., Univ. of Richmond, Richmond, Va. 23173. A taxonomic study has been undertaken of the nine nominate species belonging to Chamaesyce subsection Pleiadeniae, which has received no comprehensive study since its proposal by Boissier 125 years ago. This subsection is reputed to be transitional between Euphorbia and Chamaesyce. The species are indigenous to the cerrado of South America. Morphological, anatomical, ultrastructural, and biogeographical studies have been used to assess these species and their position within Chamaesyce. Chamaesyce caecorum is a remarkably variable species with extreme forms that show intergradation. Chamaesyce chamaerrhodos, C. setosa, C. tamanduana, and C. viscoides, which have been variously synonymized, recognized, or ignored in recent studies, are recognized as distinct species. The enigmatic Chamaesyce tamanduana appears to be very rare and is only known from the type collection. Euphorbia Chamaerodos [sic] var. hirsuta has been synonymized with Chamaesyce chamaerrhodos.

STUDIES OF RED SPRUCE/HARDWOOD ECOTONES AT SEVERAL LOCALITIES IN VIRGINIA AND WEST VIRGINIA Steven L. Stephenson, Dept. of Biology, Fairmont State Col., Fairmont, WV 26554, Harold S. Adams, Dabney S. Lancaster Cmnty. Col., Clifton Forge, VA 24422, David M. Lawrence, Dept. of Environmental Science, Univ. of Va., Charlottesville, VA 22903, Mary Beth Adams, USDA Forest Service, Timber and Watershed Lab., Parsons, WV 26287, and John D. Eisenback, Dept. of Plant Pathology, Physiology, and Weed Science, Va. Polytechnic Inst. & State Univ., Blacksburg, VA 24061. We are currently investigating patterns of species composition and distribution, ecologically important population processes, and microenvironmental gradients in permanent transects (each consisting of a series of contiguous 10 x 10 m quadrants) established across the typically abrupt and narrow spruce/hardwood ecotone at five localities in the mountains of central West Virginia and western Virginia. Primary emphasis of our research is directed toward testing three basic hypotheses: (1) red spruce communities in the mid-Appalachians are decreasing in areal extent due to encroachment of surrounding hardwood communities, (2) stress-induced growth decline in red spruce is a factor in this decrease, and (3) the direction and rate of successional change can be predicted from models developed from quantitative data obtained from field studies of spruce/hardwood ecotones. Preliminary data obtained during the 1992 and 1993 field seasons suggest that mid-Appalachian red spruce communities presently exist at least in static equilibrium with respect to surrounding hardwoods and exhibit, at some localities, advance regeneration into the hardwood communities. (Supported in part by funds provided by the USDA Forest Service.)

HIGH ELEVATION BEECH COMMUNITIES IN THE CENTRAL AND SOUTHERN APPALACHIANS. Steven L. Stephenson, Dept. of Biology, Fairmont State College, Fairmont, WV 26554 and Harold S. Adams, Div. of Science and Mathematics, Dabney S. Lancaster Cmnty. Col., Clifton Forge, VA 24422. Forest communities in which American beech (Fagus grandifolia Ehrh) is a major component of the tree stratum occur at elevations up to 1830 m in the southern Appalachians. Such communities are well-documented for the Great Smoky Mountains, where they have been the subject of a number of studies. Beech communities appear to be relatively uncommon in the mid-Appalachians, and only rarely have examples of this forest community type been described for particular localities in western Virginia. In the present study, data on the composition and structure of the vegetation were obtained for forest communities with beech present as a dominant or codominant species at one study site on Mount Rogers in Smyth County and three study sites in the Mountain Lake area of Giles County. Soils data also were obtained for the three Mountain Lake study sites.

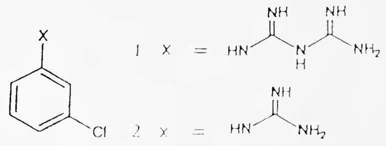
MICROFUNGAL EVIDENCE FOR THE POSSIBLE DYSFUNCTION OF SHIITAKE PRODUCTION LOGS IN VIRGINIA. R. Jay Stipes and Gonzalo Guevara-Guerrero, Dept. Plant Pathol. , Physiol. , and Weed Science, Virginia Tech, Blacksburg, VA 24061. Shiitake growers in Virginia have experienced considerable diminution of the fruiting life of oaks logs (maximum = 5-6 yrs.), and in some cases no fruiting at all has occurred. Growers tend to select on their woodlots the understory, suppressed, slow-growing, and weakened trees (cull stock) rather than vigorously growing, dominant or co-dominant trees. Since the latter prove to be highly functional shiitake log resources, we suspected involvement of competing fungi ("weed fungi") as the precluding factors in shiitake production. We aseptically biopsied sapwood (xylem tissues) cores from typically suppressed oak (Quercus spp. J and those from dominant, healthy, fast-growing ones (controls). A low percentage (23%) of control trees were colonized by fungi, whereas 100% of biopsies from suppressed trees were colonized. We theorize that these opportunists and their metabiotic successors (Hypoxylon, Graphostroma, Eutypa spp.) are precluding factors in shiitake production logs harvested from suppressed trees; research, however, is needed for confirmation.

POTENTIAL ALLEPOPATHIC EFFECTS OF MYRICA CERIFERA ON PINUS TAEDA. Kathryn S. Tolliver and D.R. Young, Dept. of Biol., VA. Commonwealth Univ., Richmond, VA 23284. Myrica cerifera forms persistent thickets on barrier islands. To evaluate potential underlying mechanisms supporting the persistence of the M. cerifera thicket seral stage, a growth chamber study examined potential sources of allelochemicals from Myrica cerifera and the interaction between allelopathy and light intensity on P. taeda seedling growth. Pinus taeda total biomass, root, and shoot biomass were significantly depressed under low light (44 μmol $m^{-2}s^{-1}$). Root biomass was significantly depressed in Myrica soil in high light (300 μmol $m^{-2}s^{-1}$); however, in high light both root and shoot biomass in Myrica soil were significantly higher in the presence of Myrica leaf litter. Thus, litter accumulation may assist replacement species in invading gaps. Low light levels and allelopathic effects may interact and contribute to the persistence of Myrica thicket seral stage by negatively impacting root growth of seedlings, thereby reducing competitive interactions for space and moisture acquisition.

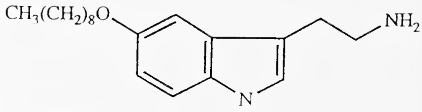
SUMMER VERTICAL DISTRIBUTION OF PHYTOPLANKTON IN CENTRAL CHESAPEAKE BAY. Mollie J. Weinstein & H.G. Marshall. Dept. Biological Sci., Old Dominion Univ., Norfolk, Va. 23529-0266. A vertical series of phytoplankton and autotrophic picoplankton samples were collected at three stations in the lower Chesapeake Bay during the summer of 1993. Results of July 1993 are reported at this time. Diatoms and chlorophytes were evenly distributed over the water column. Phytoflagellates had higher concentrations above the pycnocline. No significant increase in phytoplankton abundance was seen in association with the pycnocline. The picoplankton surface abundance varied among the stations. Overall, there were higher autotrophic picoplankton concentrations in the pycnocline region, and reduced abundance below the pycnocline. (Supported in part by the Virginia Dept. of Environmental Quality).

Chemistry

PHENYLBIGUANIDES AND PHENYLGUANIDINES: A SAFIR ANALYSIS FOR 5-HT_3 BINDING. A. Abdel-Rahman,* M. Dukat,* M. Teitler,* and R.A. Glennon. Department of Medicinal Chemistry, MCV/VCU 23298. 5-HT_3 receptors are ion channel receptors that may be involved in the control of nausea and in various mental disorders. Although a wide variety of 5-HT_3 antagonists have been developed, selective high-affinity 5-HT_3 agonists are virtually unknown. We and others independently identified mCPBG (1; Ki = 17 nM) as a novel 5-HT_3 agonist. In order to determine what structural features are important for affinity/selectivity, we systematically examined the structure of mCPBG in a structure-affinity relationship (SAFIR) study. Guanidine 2, for example, binds with high affinity (Ki = 35 nM), represents a novel class of 5-HT_3 ligands, and suggests that the intact biguanide system is unnecessary for 5-HT_3 binding affinity.

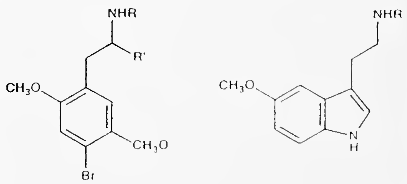


INVESTIGATION OF NOVEL SEROTONIN 5-HT1D RECEPTOR LIGANDS. Bondarev, M.;* Hong, S.;* Dukat, M.;* Teitler, M.;* Glennon, R.A. Dept. of Med. Chem., MCV/VCU; Richmond, VA 23298. Sumatriptan was recently introduced to the American market as a novel agent for the treatment of migraine. Although its exact mechanism of action is unknown, it displays high affinity for two populations of serotonin receptors (5-HT1A and 5-HT1D), and acts as a 5-HT1D agonist. In addition to difficulty in penetrating the blood-brain barrier, it has been suggested that its 5-HT1A component may detract from its therapeutic efficacy. To overcome these problems, we have developed a series of agents that binds at 5-HT1D receptors with higher affinity and selectivity than sumatriptan. For example, ALX-1323 or 5-(nonyloxy)tryptamine (NOT), binds with several-fold higher affinity and > 250-fold selectivity for 5-HT1D versus 5-HT1A receptors. Preliminary functional studies reveal NOT to be a 5-HT1D agonist. Investigation of structure-affinity relationships is currently underway.

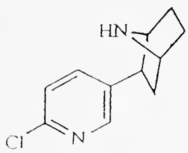


NOT

INFLUENCE OF AMINE SUBSTITUENTS ON 5-HT2A VERSUS 5-HT2C SEROTONIN RECEPTOR BINDING. M. Dukat,* H. Law,* M. El-Bermawy,* J. De Los Angeles, M. Teitler,* R.A. Glennon, Dept. Med. Chem. MCV/VCU, Richmond, VA 23298. Many ligands previously shown to bind at 5-HT2A receptors have now been found to bind with nearly comparable affinity at 5-HT2C receptors. For example, DOB (1 R = Me, R = H) binds with nearly equal affinity at both populations (Ki = 41 and 70 nM, respectively). We under took an examination of two series of N-substituted compounds (i.e. phenylalkylamines and indolylalkylamines 1 and 2) in order to identify compounds with greater selectivity. In general, amine substitution decreases receptor affinity; however certain substitution (e.g. 1, R = 4-Br benzyl, R′ = H; 2, R = 4-Br benzyl) results in compounds that bind at 5-HT2A receptors with high affinity (Ki < 1 nM) and with > 100 fold selectivity relative to 5-HT2C binding.



EPIBATIDINE: A NEW NICOTINE RECEPTOR LIGAND. Dumas, D.;* Dukat, M.;* May, E;* Glassco, W.;* Martin, B.; Glennon, R.A. Dept. Med. Chem., MCV/VCU; Richmond, VA 23298. It is speculated that nicotine receptor ligands might be of therapeutic benefit for the treatment of obesity, anxiety, and memory loss. With the exception of nicotine, few selective high-affinity agents exist. (-)Epibatidine (1), isolated from Ecuadoran frogs, shows structural resemblence to (-)nicotine (2). Molecular modeling studies reveal that the N to N distance in 1 (5.5 Å) is greater than that found in 2 (4.9 Å). This distance exceeds that previously considered optimal for the nicotine receptor pharmacophore (4.8 ± 0.3 Å) by about half a bond length. Nevertheless 1 binds (Ki = 0.025 nM) at [^{3}H]nicotine-labeled receptors with nearly 100-fold higher affinity than 2. Although our studies are still in progress, molecular superimposition and preliminary results with various structurally modified analogs suggest that it is the conformationally constrained nature of 1 that accounts for its high affinity, and that the nicotine receptor pharmacophore may require re-formulation.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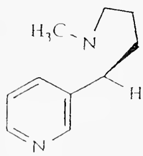
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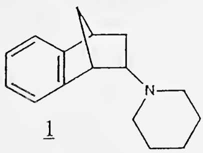
SYNTHESIS AND RE-EVALUATION OF A SPURIOUS σ RECEPTOR LIGAND. M.B. El-Ashmawy*, S.Ablordeppey*, J.Fischer* and R.A.Glennon. Dept. of Med. Chem., MCV/VCU, Richmond, VA 23298. Sigma (σ) receptor ligands have been proposed to be a new class of neuroleptic/neuroprotective agents. Recently, we identified phenylethylamines as a common pharmacophore of various σ agents and developed a number of high affinity σ-selective compounds. Meanwhile, a conformationally-restricted analogue of our phenylethylamines, 1, was reported by others to be a superpotent σ ligand (Ki = 0.075 nM). Because structure-activity relationships (SAR) developed in our laboratory would have forecast this agent to be of much poorer affinity, we resynthesized 1 as well as its individual *endo* and *exo* isomers. The low affinity determined for 1 (Ki = 66 nM) is consistent with our SAR and further suggests that the *exo* form is the higher affinity isomer.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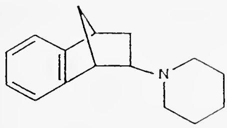
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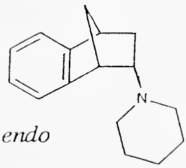
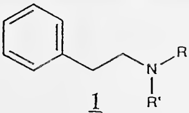

endo

DESIGN AND SYNTHESIS OF SUPERPOTENT σ-1 RECEPTOR LIGANDS. M.B. El-Ashmawy*, S.Ablordeppey*, A.Ismaiel*, J.Fischer* and R.A.Glennon. Dept of Med. Chem., MCV/VCU, Richmond, VA 23298. Current interest in sigma (σ) receptors relates to possible involvement in psychiatric disorders and regulation of motor behavior. Problems hampering σ research are the lack of high-affinity agents and identification of multiple populations of receptors (σ_1 and σ_2). We have previously identified phenylethylamine 1 as the binding pharmacophore of benzomorphans and other σ agents. In the present investigation, different phenylalkylamines were designed and evaluated for σ_1 binding, using [^{3}H]pentazocine as radioligand. Most showed higher affinity at σ_1 than at "overall σ" receptors, e.g. phenylpentylamine 2, Ki = 0.17 nM. Common structural features important for σ_1 binding were identified, a possible ligand pharmacophore model has been proposed, and a novel class of superpotent σ_1 agents (Ki < 1 nM) was developed. In fact, the phenylpentylamines represent the highest affinity σ_1 ligands reported to date. (Supported by MH-45225.)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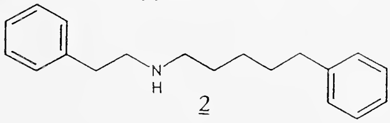
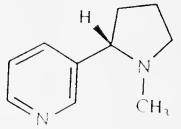

2

STRUCTURE-AFFINITY RELATIONSHIPS OF SIMPLE NICOTINE ANALOGS AT CENTRAL NICOTINE RECEPTORS. W.J. Fiedler*, M. Dukat*, B. Martin*, R.A. Glennon. Dept. of Med. Chem., MCV/VCU, Richmond, VA 23298. Central nicotine receptors are involved in memory, learning and neurodegenerative disorders such as Alzheimers disease. The development of structure-affinity relationships (SAFIR) for [^{3}H]-nicotine receptor binding should aid the development of novel nicotine agents. Ring opening of the pyrrolidine ring of (-)nicotine (1; Ki 2 nM) results in retention of, but a reduction in, affinity. For example, optimal substitution in 2 is R = Et, R' = Me (Ki = 30 nM) Lengthening one R chain beyond propyl abolished affinity. Secondary amines were also inactive; aromatic substituted analogs of 2 were of lower affinity than 2. Further study is necessary to complete the formulation of SAFIR. Development of conformationally restricted analogs are of particular interest to further delineate the bioactive conformation of 1. (Supported in part by funds from CIT/TDC.)



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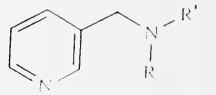
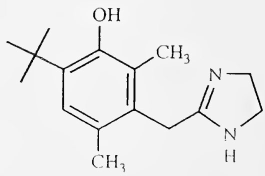


2

WHAT DO SEROTONIN RECEPTORS LOOK LIKE: A COMPARISON OF MOLECULAR DYNAMICS SIMULATIONS OF MEMBRANE BOUND RECEPTOR MODELS. J. L. Herndon,* R. B. Westkaemper,* R. A. Glennon. Dept. of Medicinal Chemistry, Medical College of Virginia, Virginia Commonwealth University, Richmond, VA 23298-0540. Serotonin 5-HT_{2A} receptors are members of the guanine nucleotide regulatory protein-coupled family of receptors (GPCR) and have been implicated in a variety of central and peripheral functions, making them attractive targets for structural modeling studies. Sequence alignments based on hydrophobicity patterns and helical turn potentials were used to construct 3-dimensional models of the human 5-HT_{2A} receptor using the experimental structure of bacteriorhodopsin as a template. Molecular mechanics minimizations followed by molecular dynamics simulations gave qualitatively different results that depended on the force-field used [Tripos' Maximin2, Tripos' Kollman united atom (Amber3.1), Insight/Discover's cvff]. The best model obtained using this approach is compared to similarly treated models constructed using sequence homology and/or the low resolution experimental structure of bovine rhodopsin as a template.

A STRUCTURE-AFFINITY RELATIONSHIP INVESTIGATION OF BENZYLIMIDAZOLINES AS 5-HT1D RECEPTOR LIGANDS. H. Law,* M. Dukat,* M. Teitler,* and R.A. Glennon, Dept. of Med. Chem., MCV/VCU, Richmond, VA 23298. 5-HT1D receptors are one of the most recently discovered serotonergic receptors and agents that bind selectively at 5-HT1D receptors may be potential drugs for the treatment of migraine. Unfortunately, there have been few reports of high-affinity selective ligands. Oxymetazoline (1, Ki = 1.1 nM), although non-selective, is a very high affinity 5-HT1D ligand. In the present investigation, we prepared a series of oxymetazoline analogs where 1 was systematically abbreviated or modified in such a way that we might determine the contribution to 5-HT1D binding of each of the various substituents. In this manner, it might eventually be possible to design agents with greater selectivity. Results suggest that the entire intact molecule is necessary for high affinity.



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Computer Science

EFFICIENCY ISSUES IN DETERMINING DATA EQUIVALENCE OF BINARY SEARCH TREES. Juanita Avila and Rita M. D'Arcangelis, Department of Computer Science, Mary Washington College, Fredericksburg, VA 22401. Binary trees are called equivalent if they have the same topology and the information in corresponding nodes is identical. A recursive algorithm is known to exist which will determine whether two binary trees are equivalent. Binary trees are called 'data-equivalent' if they have possibly different topologies and yet contain the same data. Research was undertaken to develop iterative, linear time and bounded space algorithms for determining data equivalence of ordinary binary search trees as well as threaded binary search trees. The algorithms developed are presented, and the rationale for the strategy used is discussed.

ILLUSTRATING ABSTRACT DATA TYPES USING MICROSOFT VISUAL C++. Tiffany Bond and Rita M. D'Arcangelis, Department of Computer Science, Mary Washington College, Fredericksburg, VA 22401. Microsoft Visual C++ is an object-oriented programming language which contains necessary abstraction, encapsulation, modularity, and inheritance features, plus a Windows-based application development and execution environment. Experiments in combining the built-in classes and object instances with programmer-defined classes and objects have produced a useful tutorial program: an interactive, menu-driven program which illustrates how several important data structures, such as stacks and queues, can be implemented in this language. The program will serve as a practical guide for instructors on implementing abstract data types in an object-oriented environment. The program will also benefit beginning Computer Science students because they will be able to select data types and then observe and affect the behavior of the structures containing those types during program execution.

ERROR FREE EDITING USING STED (SYNTAX TEXT EDITOR). Shawn Chambliss, Samone Jones, and Larry Morell, Dept. of Computer Science, Hampton University, Hampton, Va. 23668. STED is a syntax-directed editor that ensures the user will produce syntactically correct programs by allowing only valid constructs to be entered. STED is novel in that it is language-independent: it can be instructed to check the structure for any programming language. Valid constructs are defined by a BNF-like grammar, augmented to include format rules to describe how the constructs are to be displayed. STED is implemented in Turbo Pascal, using object-oriented programming and runs on a PC.

INTELLIGENT LOGIC TUTOR. Ying Gu & Rhonda Eller, Department of Computer Science, Randolph-Macon College, Ashland, VA 23005. This framework for a tutoring system is designed to help student users with formal logic proofs by incorporating techniques from theoretical works of planning, plan recognition, and plan repair. It adapts a formal AI framework for use in a learning tool with an intelligent user interface. The student may ask the system to do a complete proof, to provide guidance only when needed, or to judge and optimize an established proof. Two types of plans are used by the system: rule plans and strategy plans. Each rule plan sets specifications and grammar for an individual logic rule. Any attempt by the user to apply a logic rule in a syntactically incorrect manner results in temporary suspension of proof construction until the error is corrected by the user with help from the system. Strategy plans encode relationships between sets of formal logic rules, developed from analyzing the strategy used by humans in construction of correct, optimal proofs. Each line in the user's proof will be assigned a weight. Weights reflect the similarities in the user's proof and the system's view of the optimal proof, the system's recognition of the correctness of the user's partially constructed proof, and the system's confidence in the rules applied to create the user's proof. In cases when proof repair becomes necessary, the line with the lowest weight is first considered for removal. Next, all descendent-lines derived from it are removed. Unlike the traditional AI resolution theorem proving approach where dependency backtracking is widely used, our system builds proofs with the forward-chaining technique which starts from the premises and attempts to reach the desired goal state. By this method, we can effectively model the direction of the human student's thought processes and thus provide advice to the student about what went wrong or could be optimized in his/her particular proof.

IDENTIFICATION AND REMOVAL OF HIDDEN SURFACES FROM THREE DIMENSIONAL OBJECTS. Laura A. Keiner and Marsha Zaidman, Department of Computer Science, Mary Washington College, Fredericksburg, VA 22401. Hidden surface removal is an essential process to render realistic images on a graphics system. Many algorithms exist to remove surfaces, which vary depending upon the particular application. HP Starbase is the graphics package available at MWC, which contains procedures to implement the Z-buffer algorithm to solve this problem. While the Z-buffer effectively handles most graphical situations, the amount of memory used to set up the buffer is immense. Each element of the buffer represents the depth of a particular pixel. The system at MWC does not support the Z-buffer. Therefore, hidden surface removal must be accomplished without the help of HP Starbase's predefined procedures. An alternative solution is using a depth sorting method such as the painter's algorithm. Backface surfaces are first removed by examining the direction of the polygon's normal vector. Then,the remaining polygons are sorted and drawn according to their depth on the screen.

Education

PROJECT SCIENCE AT DSLCC--PHASE II. H. S. Adams and J. S. Barnes*, D. S. Lancaster Cmnty. Col., Clifton Forge, VA 24422. During its second year, full and part-time faculty at Dabney S. Lancaster Community College continued to develop and incorporate modules into their courses to help students in the areas of: (1) overcoming deficiencies in science knowledge; (2) increasing positive attitudes toward science; and (3) developing critical thinking skills. In all, over thirty percent of the DSLCC faculty (including some part-time faculty who teach dual enrollment courses) have participated in developing modules during the two years of our program. Modules were developed in anatomy and physiology, nutrition, economics, business law, history, and general biology this past year. Additionally, three films were shown and nine speakers from various disciplines presented public programs for students and general public alike with attendance averaging around 100 persons (primarily students). These speakers also conducted classroom presentations for specific disciplines generally outside their area of expertise. Post-test assessment results are not yet complete, but general response to the program by both students and faculty has been very positive. (Supported in part by funds provided by the State Council on Higher Education in Virginia.)

PARTNERSHIP FOR EXCELLENCE: A MODEL FOR AUTHOR VISITATION PROGRAM. Krishan M. Agrawal, Virginia State University, Petersburg, VA 23806 and Wallace O. Pendleton, Jr., Chesterfield County Schools, Chesterfield, VA 23832. A description of how a school system, local book store, and a publisher of science books work together to foster student interest in science. An author of a current popular science book is invited to visit school classrooms to present topics covered in his or her book to the students. The author later participates in a panel discussion attended by a larger audience, which includes students who have read the book, educators, and scientists. The panel discussion covers a broader range of topics, including the current status of research in the related field.

CHANGING ASSESSMENT METHODS IN MATHEMATICS AND SCIENCE (V-QUEST). Eurice J. Dawley, Norview M.S., 6325 Sewells Point Road, Norfolk, VA 23513, & Emily Pugh, Norview M.S., 6325 Sewells Point Road, Norfolk, VA 23513. Some conventional assessment methods are not the best measurement tools to test for mastery of objectives taught or skills learned. For too many years, the only assessment instruments used by many teachers on a regular basis have been multiple choice tests, matching, completion, or tests structured to give a single "right" answer. Too often effort is unrewarded. Science laboratory activities are difficult to assess. Grading is perceived as one of the most painful components of the educational act for teachers and students. It does not have to be that way. Many teachers of science and mathematics want to identify alternative assessment procedures to use. There are several initial changes that can be made to existing measurement instruments with relative ease. These changes will afford us opportunities to identify behaviors and skills used to formulate and execute a plan to organize data and describe the solution set.

PERCEPTIONS AND ATTITUDES OF UNDERGRADUATE SCIENCE FACULTY TOWARD SCIENCE TEACHING: ESTABLISHING A BASELINE FOR THE INTERDISCIPLINARY SCIENCE AND MATHEMATICS EDUCATION PROJECT (V-QUEST). Susan C. Eriksson, Dept. Geological Sciences and Virginia Tech Museum of Natural History, and George E. Glasson, College of Education; Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061. Faculty teaching introductory science courses were interviewed in order to assess attitudes and perceptions about their own teaching, the students and how their courses should be changed. Although several positive attitudes were voiced (satisfaction in teaching, 'getting through' to a few students, and some changing techniques in teaching over the years), faculty mainly expressed feelings of frustration in teaching large sections, little pedagogical training in their careers, and pressure to compromise standards. They felt students are not conscientious, expect teachers to be entertainers, are disruptive and don't get intellectually involved in their courses. Faculty also expressed interest in teaching in smaller sections, relating laboratory experiences more closely to lectures, and improving the pedagogical skills of teaching assistants.

PERCEPTIONS AND ATTITUDES OF UNDERGRADUATE SCIENCE STUDENTS TOWARD SCIENCE: ESTABLISHING A BASELINE FOR THE INTERDISCIPLINARY SCIENCE AND MATHEMATICS EDUCATION PROJECT (V-QUEST). George E. Glasson, College of Education, Va. Polytechnic Inst. & State Univ., Blacksburg, VA 24061-0313, & Susan Eriksson, Dept. of Geol. Sciences, Va. Polytechnic Inst. & State Univ., Blacksburg, VA 24061-0420. In an effort to assess the perceptions and attitudes of pre-service teachers toward undergraduate science courses, fourteen students were interviewed. Of these students, three were pre-service elementary teachers, seven were pre-service middle school science teachers, and four were pre-service high school science teachers. The following themes emerged from the interviews: (1) lecture classes are too large and impersonal; (2) lecture and lab classes are disjointed; (3) lab classes are "cookbook" rather than investigative; (4) students learn more in upper level lab classes with investigative approach; (5) information presented is unrelated to real world problems; (6) more interdisciplinary approach needed for science programs; (7) too much emphasis on multiple-choice tests; (8) women should be encouraged in science; (9) many graduate teaching assistants not qualified to teach; and (10) teaching is not a priority for professors.

ENCOURAGING QUESTION ASKING AND WRITING IN THE SCIENCE CLASSROOM Kenneth Lawwill, Chantilly High School, Fairfax Co. Public schools; Thomas Teates, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061-0313. Student apathy towards science may be reduced by allowing more ownership of the topics. Permitting students to ask their questions and seek their answer should contribute more to long term than just emphasising the questions the teacher or text believe are important. Literacy requires asking. Several techniques to encourage questioning, including student writing schemes, will be discussed. Allowing students more opportunities to individualize their learning and expression can contibute to more meaningful construction of knowledge.

INVESTIGATING HIGH SCHOOL STUDENTS' PERCEPTIONS OF THEIR SCIENCE EDUCATION-INITIAL VQUEST STUDY. Woody McKenzie, Southwest Va. Governor's Sch., Dublin, Va. and Dr. George Glasson, Div. of Curriculum and Instruction, Va. Poly- technic Inst. & State Univ., Blacksburg, VA . Students from two high schools were interviewed in an open-ended format both singly and in small groups to gain insight into their perceptions of their science education. Seven topics were addressed including important memories/experiences, science literacy, goals, and the relevance of their education to their world outside school. Interviews were transcribed and the data was systematically explored. Ability to self-evaluate was noted as a factor limiting the richness of students' responses in some cases; however, some students were capable of in-depth critical evaluation of their educational experiences. From this data, it was concluded that these particular students view their science education as not related to their outside school world, but as important preparation for their future. They perceive motivated, competent teachers as more important to learning than the specific course material. They have little conscious memory of science courses before freshman year. Most believe their earth science course was not worthwhile. Evidence of reform was noted in students' experiences with an open-ended physics laboratory.

A BLINDING REFORM: A HISTORICAL LOOK AT LABORATORY AND INTERDISCIPLINARY SCIENCE INSTRUCTIONAL METHODS IN LATE 19TH CENTURY AMERICA. Pamela C. Turpin, Dept. of Chem., Roanoke College, Salem, Va. 24153-3794. One hundred years ago, a reform agenda of science educators in the United States was the institution of the laboratory method of science instruction into public schools. Seen as the ideal instructional method for science teaching, this reform initiative seemed to impact adversely on considerations and implementation of other alternatives to reform science teaching in secondary schools during the late-nineteenth century. It seems that this new and different instructional method appeared so bright and right to late-nineteenth century science educators that its aura overpowered, overshadowed, stifled and blinded reformers to other creative suggestions and recommendations that were not at the forefront of the reform movement. The overwhelming support of science educators for the laboratory method acted to inhibit implementation of other alternative means of instruction at the secondary level. One victim of this blinding reform was interdisciplinary methods and courses in secondary school science. I refer to this type of reform as a *blinding reform.*.

PERSPECTIVES ON COLLABORATION IN AN STS LANDFILL RESTORATION PROJECT: SCIENTIST, CLASSROOM TEACHER, AND RESEARCHER. Beatrice Taylor & Mara Sabre, Depts. of Educ. and Biol., Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061-0313, & John Kowalski, Roanoke Valley Gov. Sch., Roanoke, Va. 24015. Being a part of a community involves the identification of community problems and negotiating solutions that contribute to the public good. The closing of the Roanoke Regional Landfill and the building of a spur across it to Virginia's Explore Park constitutes such a community problem. Students at the Roanoke Valley Governor's School participated in a study in which they studied the problems of opening, maintaining and closing landfills. They took field trips to the old landfill, the new one under construction, and Explore Park. Guest lecturers also visited the school. Using this information, students generated experiments using seeds that are being considered for use on the closed landfill. This was a year long study in which the classroom teacher, the scientist, and the researcher planned and taught collaboratively. They share insights on how the scientist and researcher become a team with the teacher and students. The students culminated this unit by sharing results with representatives from the landfill authority, the board of supervisors, and Explore Park. (Supported by DuPont and Mobil Education Programs and the Roanoke Solid Waste Mgt. Brd.)

THE BREADTH OF SCIENTIFIC LITERACY - SOME EXPERIENCES AND ACTIVITIES THAT ILLUSTRATE THE NEED FOR SCIENCE CURRICULUM REFORM Thomas G. Teates, Div. of Curriculum and Instruction, Va. Polytechnic Institute and State Univ., Blacksburg, VA 24061; Kenneth S. Lawwill, Chantilly High School, Chantilly, VA 22021. Science teachers, science educators, and scientists do not recognize their groups' lack of "literacy." Expertise in one endeavor among the many in science does not constitute "literacy." Rather than mastery of a superficial body of facts, "literacy" need s to be encouraged as the goal that requires both being capable of understanding and the desire to try to keep on learning about our environment. To restrict one's learning to a field of specialty is to ensure one's loss of literacy. Education, including that in science, needs to prepare and challenge students at all levels to continue their informal, general learning about the environment.

Environmental Science

METHANE EMISSIONS ASSOCIATED WITH *SAGITTARIA GRAMINEA*, MICHX., ARROWHEAD, UNDER ENRICHED ATMOSPHERIC CO_2. Kelly M. Alexander, K.E. Brunke* and G.J. Whiting*, Dept. of Biol., Chem., and Envir. Sci., Christopher Newport Univ., Newport News, VA 23606. Atmospheric CO_2 levels are expected to double by the mid-21st century. Elevated atmospheric CO_2 is known to significantly affect plant physiological functioning, which may impact the soil microbes that metabolically produce methane. To date, best estimates suggest that wetland plants and agricultural rice contribute 40-50% of the total methane emitted to the atmosphere each year. We tested the hypothesis that increasing atmospheric CO_2 would translate into higher methane production and emission by measuring below ground concentrations and above ground emissions associated with *Sagittaria graminea* under ambient and two times ambient CO_2. Results suggest a positive correlation between increased atmospheric CO_2 and increased methane production and emission. These results imply greater contributions of methane to the atmosphere from these sources under future projected atmospheric CO_2 levels.

ISOLATION OF KEROSENE-DEGRADING BACTERIA FROM KEROSENE-CONTAMINATED SOIL. Keitha M. Dattilo and Lynn O. Lewis, Dept. of Biological Sciences, Mary Washington Col., Fredericksburg, VA 22401-5358.

In 1989, a rupture in a kerosene pipeline caused contamination of 17,000 yd^3 of soil near the Rappahannock River above Fredericksburg. The soil has been stored in a large, covered mound since that time. Core samples were collected from several locations within the mound, and all soil samples were mixed for inoculation into a minimal medium with 0.05% yeast extract and kerosene as the carbon sources. On the first attempt to isolate organisms, many motile rods and a possible cyanobacterial species were found. When plated on T-soy agar (TSA) or minimal salts agar (MSA), five characteristic colonies, ranging from filamentous to typical bacterial-type, were evident. A second isolation trial is underway using kerosene as the sole carbon source. Preliminary plating on TSA has revealed four distinct colonies of rod-shaped bacteria. Currently, identification of all isolated microbes is being pursued.

A GREENHOUSE STUDY TO DEVELOP SEEDING RATES ON DISTURBED SOILS: A CASE STUDY OF A LANDFILL AND TWO MINE SITES. Ken Hyer, Mara Sabre, and John Cairns, Jr. Univ. Ctr. for Environmental and Hazardous Materials Studies, Va. Polytechnic Inst. & State Univ., Blacksburg, VA 24060.
Topsoil from three disturbed sites and a control soil was used to conduct greenhouse germination tests on monocots and dicots that were either native to Virginia, or common in revegetation projects. The data generated were to be used to recalculate seeding rates on revegetation projects, helping to assure adequate coverage. Variability in percent germination of species between the four soil types was large. Also, the species often deviated from the distributors' published germination rates. Results from soil analyses established no relationship between the soil and the observed germination rate. Germination studies using appropriate soil provides a more acceptable method of determining a seeds expected percent germination than either the distributor's reported percent germination or a soil analysis. A short-term greenhouse germination study is an inexpensive yet informative method of developing appropriate in-field seeding rates on restoration projects.

MACROINVERTEBRATES OF ACCIDENTAL WETLANDS ON SURFACE MINED AREAS OF SOUTHWESTERN VIRGINIA--PRELIMINARY RESULTS. David H. Jones, R.B. Atkinson, J. Cairns, Jr., Univ. Ctr for Environmental and Hazardous Materials Studies, VA Tech, Blacksburg, VA 24061.
Surface mining in Southwest Virginia prior to the passage of the Surface Mining Control and Reclamation Act of 1977 (SMCRA, P.L. 95-87) has resulted in the formation of accidental wetlands. Macroinvertebrate inventories of nine accidental wetlands were made in July and September 1993 using three replicate sweeps of a D-frame net. Species richness was compared to water chemical parameters, physical parameters, water depth and fluctuation, and macrophyte richness and biomass. Results indicate that drawdown variations, conductivity, and maximum depth influence macroinvertebrate species richness. All orders of aquatic insects were present except Plecoptera. A total of 53 taxa was identified. These findings are being used in the development of design specifications for wetlands to be constructed in surface mine reclamation.

ADSORPTION BEHAVIOR ON IRON OXIDE AND ALUMINA., ESHETE MATTHEWOS & W.H.LEUNG Dept. of Chemistry, Hampton Univ., Hampton, VA 23668. Adsorption phenomena play an important role in the aquatic system. It has been shown that metallic oxides show various degree of adsorption to different trace constituents like Humic acid, metals, and phosphate at different pH. Extended experimental investigation of these metallic oxides to systems containing more than one potential adsorbate can give understanding unattainable from single adsorbate laboratory model. We have been investigating Humic acid adsorption on iron oxide and aluminum oxide in the presence and absence of phenol or Cu at different pH. Results suggest that the presence of phenol does not have significant effect on the adsorption of Humic acid on alumina while the presence of Cu found to facilitate the adsorption of Humic acid. The results of these adsorption experiments carried out at both pH 6 & 8 could be fitted to Langmuir adsorption isotherm.

EFFECTS OF WATERSHED URBANIZATION ON STREAM FISH COMMUNITIES IN PRINCE WILLIAM COUNTY, VIRGINIA. Donald R. Morgan, Dept. of Biol., George Mason Univ., Fairfax Va. 22030, D.P. Kelso, Dept. of Biol., George Mason Univ., Fairfax Va. 22030, & R.C. Jones, Dept. of Biol., George Mason Univ., Fairfax Va. 22030. Prince William County Va. possesses three watersheds, Neabsco, Powells and Quantico each affected by vastly different levels of development. These watersheds offer a unique opportunity to assess the negative impacts on streams, associated with increased urbanization. To evaluate the impact of such urbanization, this study incorporates an index of biological integrity (IBI) as the principal component of the analysis. The IBI integrates twelve metrics of stream fish assemblages for assessing stream quality. Relationships among sites were also explored using principal component analyses (Correlation matrix) on fish abundance and presence-absence data. The results indicate major differences in IBI scores among sampling stations were related to watershed area. Sites in smaller watersheds show great biotic similarity, while substantial differences were observed among sites in larger watersheds. Sites in Large watersheds showed little difference in IBI scores between the suburbanized Neabsco and the forested reference watershed Quantico Creek. Stream passage through riparian parkland resulted in increased IBI scores. Sites located below BMP's had IBI scores that ranged from high to low. High IBI values were associated with favorable habitat conditions found below many wet ponds, while a low score was associated with a degraded stream reach below several dry ponds.

REMOVAL OF WATERBORNE RADON BY REVERSE OSMOSIS AND ACTIVATED CHARCOAL Douglas Mose and George Mushrush, Department of Chemistry, George Mason University, Fairfax, VA 22030. Reverse osmosis is a process by which water is forced under a pressure sufficient to overcome osmotic pressure through a semipermeable membrane, leaving behind imputities. Removal effectivess for dissolved ionic ans suspended impurities is typically above 90%. A two year study in a home with waterborne (well water) radon of @4000 pCi/l shows that the reverse osmosis unit removes almost all of the radon (90%+). In contrast, experiments using activated charcoal in the same home can with some types of charcoal initially show a 90%+ radon reduction, but the removal effectiveness decreases monthly, to @50% after two years. Also, the gamma radiation levels quickly increase outside of the activated charcoal tank, and could pose health problems. Although the cost of a reverse osmosis unit (@$2000) greatly exceeds similar capacity activated charcoal units (@$500), the advantages of lower waterborne radon, more easily replaced components and no gamma-ray health problem suggest that the reverse osmosis method of radon removal has a lower cost/benefit ratio that the activated charcoal method.

THE EFFECTS OF DIMILIN[T] APPLICATIONS ON FOREST FLOOR LITTER ARTHROPOD POPULATIONS IN PRINCE WILLIAM COUNTY, VA. Larry L. Rockwood and Kim Largen, Dept. of Biol., George Mason Univ., Fairfax, VA. 22030. Diflubenzuron (Dimilin[T]) has been used to suppress gypsy moth (*Lymantria dispar*) populations in Prince William County since 1986. A chitin inhibitor, Dimilin, has no effect on plants or vertebrates, but may pose a threat to non-target arthropods. To determine if leaf-litter arthropods are affected, ten plots were established in each of three forested areas (30 total plots) in western Prince William and eastern Fauquier Counties in 1992. Including 1992, the Prince William sites had been sprayed for 3 and 5 consecutive years. The Fauquier (control) site has never been sprayed. Leaf litter was collected on 1 pre-spray and 5 post-spray dates. Arthropods were extracted using Berlese funnels and sorted to order. Mean absolute abundance and mean relative abundance were analyzed with ANOVA after appropriate transformations. Results show no consistent trends. Mean absolute abundance of total arthropods for control versus spray sites was not significantly different except for one post-spray date, in which the 5-year spray site had a significantly larger mean than the control site. Although some taxonomic groups have significantly lower mean absolute abundances on spray plots for occasional pre- and post-spray dates, other taxonomic groups actually have higher means on sprayed plots. At present, spraying with Dimilin shows no detectable effects on litter arthropods.

EFFECTS OF WATERSHED URBANIZATION ON STREAM MACROBENTHOS IN PRINCE WILLIAM COUNTY, VA. Steve Winesett, Donald Morgan, R. Christian Jones, Biology Department, George Mason Univ., Fairfax, Va. 22030. Macroinvertebrate stream communities were used to asses the impacts of stormwater runoff and suburban nonpoint pollution in three watersheds of varying development in Prince William County Va. Samples were collected using kick nets at predetermined sites during May and June. Macroinvertebrate ratings were calculated using the EPA bioassessment protocol II and site relationships were compared using Principal Component analysis (PCA).

Results showed that macroinvertebrate communities were influenced by both watershed area and level of disturbance from suburban activities. PCA using abundance data for insect families occurring at more than 5 stations showed that the most impacted watersheds were of small size and occupied a tight cluster indicating similarity with one another. Larger watersheds exhibited clear differences associated with degree of suburban development with the most degraded sites being located in the highly developed Neabsco creek basin.

Geography

SPATIAL DISTRIBUTION OF HISPANICS IN THE CITY OF HARRISONBURG, VA. Amy B. Cohen and Dominic Pisciotta, Dept. of Geography, James Madison Univ., Harrisonburg, Va. 22807. While extensive studies have been made into the location of minorities in large cities, the distribution of Hispanics in non-metropolitan cities has been largely ignored. This study uses U.S. Bureau of Census population data for Harrisonburg to locate groups of Hispanics within the city. The income statistics from the census were used to identify spatial distribution of Hispanics according to their incomes. Substantial numbers of Hispanics were found in approximately ten of the twenty-four block groups comprising Harrisonburg. The per capita income for these block groups is generally lower than that of the city as a whole, and the income of Hispanics is significantly lower than that of the general population. Because little information is currently available and because of the disparity in income levels between Hispanics and the general population, more extensive studies must be made in non-metropolitan cities.

THREE TECHNIQUES OF IMAGE MERGING: LANDSAT THEMATIC MAPPER AND SPOT PANCHROMATIC DATA. Warren Crowder and William Kane*. Dept. of Geography, James Madison Univ., Harrisonburg, VA 22807. The High Frequency Merge, IHS2RGB, and a composite of the two methods are discussed. Our goal was to maintain the spectral characteristics of the TM data (30 x 30 meter pixel size) while adding the spatial characteristics of the SPOT Panchromatic data (10 x 10 meter pixel size). In our study the High Frequency method provides the best images for interpretation. Our training site, Winchester, Virginia, provided a balanced sample in agriculture, forest and urban settings to make good comparison between each of the methods. Overheads and handouts will be used in the presentation.

TECHNOLOGY TRAINING METHODS: AN UPDATE. Glen C. Gustafson, Dept. of Geography, James Madison Univ., Harrisonburg, Va. 22807. Some of the basic methods of computer technology training for undergraduate college students are discussed and evaluated. The training methods are appropriate for such tasks as: video digitizing hard-copy aerial photography, using tablet digitizers on maps and airphotos, digital photogrammetric plotting, digital mapping from satellite imagery, and digital image enhancement. The most useful training methods in this environment have been found to be: demonstrating the software with an LCD projection panel, providing flow diagrams for the processing steps, and using an example session listing to get the student through his or her first run of the program.

ENVIRONMENTAL ASSESSMENT OF THE RIPARIAN ZONE OF THE SOUTH FORK OF THE SHENANDOAH RIVER, VA. Matthew J. Humke and Dr. Jack Gentile. Dept. of Geography, James Madison Univ., Harrisonburg, VA 22807. Various methods have been used to measure the environmental quality of riparian zones, but the most effective has been the Environmental Impact Assessment Inventory, which selects certain environmental variables (i.e. slope, vegetation type, water quality) and assess each individually. The objective of this study was to develop an inventory unique to the riparian zone of the South Fork of the Shenandoah River located near Elkton, VA. Eleven environmental variables were selected, placed into one of four classes, and assigned a impact value with larger values indicating high environmental impact and lesser values indicating little or no environmental impact. Once completed, the eleven variable values were added, with the final value indicating the environmental "quality" of the area. The developed inventory was then applied to two homogenous branches of the river.

TOWARDS THE PREDICTION OF BURGLARIES IN HARRISONBURG, VIRGINIA Stephen E. Wright, Dept. of Geol. & Geog., James Madison Univ., Harrisonburg, Va. 22807. The purpose and problem of this paper was to examine whether variables used to predict burglaries in large and medium size cities were adequate predictors of burglaries in small town Harrisonburg, Virginia. Burglary data for 1990 were provided by the Harrisonburg city police. Social-economic data were acquired from the United States 1990 Census of Population and Housing. The population consisted of 225 reported burglaries for the year 1990. In order to measure the concurrent effects of the nine selected independent variables on one dependent variable (Burglaries), the regression analysis technique was chosen. The results indicated that, individually, the most significant predictor of Harrisonburg burglaries were *residence in 1985*, *median year structure was built* and *median family income* (their beta coefficient were 0.0124, 0.0185, and 0.0207 respectively, significant at $p \leq 0.05$).

Geology

NIOBIUM AND TANTALUM DISTRIBUTION IN COLUMBITE - TANTALITE FROM THE MOREFIELD PEGMATITE, AMELIA, VIRGINIA. J. M. Ayers, Dept. of Geol./Geog., James Madison University, Harrisonburg, Va. 22807. Samples of columbite - tantalite from the Morefield Pegmatite in Amelia county, Virginia were analyzed for Ta, Nb, Mn, Ti, Fe and Sn. One hundred and twenty samples were examined for elemental zoning and compositional variation. The samples were collected from 49 sites along the 65.9 meters of pegmatite exposed at the 60 foot mine level. The analyses shows a relationship of Ta to Mn, Ti and Sn. Niobium also shows a correlation with Fe. Greater chemical variation occurs in the NE section of the pegmatite; the SW section is typified by less variation. The samples tend to be more chemically homogenous. Tin occurs only in the NE section which coincides with a marked increase in Ti. The samples tend to be more Ta rich near the quartz core and more Nb rich away from the core.

POTENTIOMETRIC INVESTIGATIONS ON A TRAVERSE NEAR THE NORTH RIVER. Rachel L. Callahan, Michael L. Maloy, Dept. of Geology and Geography, James Madison University, Harrisonburg, VA 22807. A preliminary study examined selected marginal wetland soils for their relationships between a fluctuating water table, soil type, and geomorphology. Eleven piezometers were installed and monitored on ancient floodplains and terraces of the North River in Rockingham County, Virginia. Examination of soil classifications, gradation analyses slug tests and recorded rainfall data have yielded the following theories: 1) Sandy soils have a greater value of hydraulic conductivity than soils with a high clay content. 2) The water table responds more quickly to moisture in a sandy soil than a clayey soil. 3) Location of mottling and manganese concretions in clayey soils corresponds to the existence of a water table. 4) Cumulative rainfall for the rainy season directly influences values of hydraulic head.

CREATIVE WRITING: A TEACHING AND LEARNING TOOL IN INTRODUCTORY GEOLOGY. Roseann J. Carlson, Debra F. Duffy and Samuel L. McKay, Geophysical Sciences Department, Tidewater Community College, 1700 College Cres. Va. Beach, Va. 23456. Recently TCC faculty members from several disciplines participated in a State funded project known as "Writing to Learn" (WTL). The participants integrated writing as a learning tool into traditionally taught lectures. Writing assignments were evaluated on content alone and took the form of letters to classmates or instructors, poems, journals, summaries and test questions. Creative writings such as these when incorporated into introductory geology lectures have proven useful in helping students discover and articulate difficult geologic concepts. A study conducted in Fall of '93 compared a traditionally taught physical geology lecture class to a lecture class using WTL assignments. Results indicated the WTL lecture class increased in the number of C to B grades over the traditionally taught lecture class. Student evaluations and comments concerning these assignments tend to be positive. This suggests that creative writing can have an impact when used in the introductory lecture class.

HYDRAULIC CONDUCTIVITY AND RETENTION OF A HYDROCARBON FUEL IN SOILS. Roger E. Decker & Dr. W. Cullen Sherwood, Dept. of Geology, James Madison Univ., Harrisonburg, VA 22807. The potential exists for many groundwater sources to become contaminated by liquid hydrocarbon products. The movement of these fluids through unsaturated soil is a complex process and many aspects are poorly understood. An experimental model is presented which analyzes mobility of diesel fuel in two common western Virginia soils. A sandy soil (Millrock Series) and a clay soil (Frederick series) were tested for gravitational saturation and hydraulic conductivity under varying soil moisture conditions. An increase in both saturation rates and hydraulic conductivity of the soils tested was found to be directly related to an increase in moisture content. It is concluded that the increased velocity of fuel movement is related to the lack of adsorption of the hydrocarbon to soil mineral surfaces when water is present. Water, due to its substantially higher dipole moment apparently adheres to the mineral surfaces and acts to facilitate the movement of hydrocarbon liquids through the system.

ANTHROPOGENIC EFFECTS ON STREAM PIRACY IN A SMALL WATERSHED IN SOUTHERN ILLINOIS, L. Scott Eaton, Dept. of Geology and Geography, James Madison University, Harrisonburg, VA 22807. Wolf Creek river basin, located in northeastern Alexander County, Illinois, has undergone a series of rapid geomorphic changes related to anthropogenic activities such as stream channelization, logging, and intense farming practices. Studies of aerial photographs indicate that a tributary of Wolf Creek was lengthened by 25% (350 m) between the years of 1938 and 1956 by a combination of headward erosion and stream piracy. A 2.0 m knickpoint in the tributary channel, migrating upstream at a rate of 7.9 m/yr, marks a geomorphic transition between the upper and lower reaches of the tributary. Above the knickpoint, channel widths (5.3 m) and depths (1.1 m) are small, whereas below the knickpoint, the channel is substantially wider (7.4 m) and deeper (1.8 m). The current incision of the tributary probably reflects headward erosion initiated where the mouth of the incipient channel spilled off the floodplain surface at the confluence of the deeper main channel of Wolf Creek.

LAND CLASSIFICATION OF THE JAMES RIVER FACE REVEALS THE EFFECTS OF PAST CLIMATES ON THE BLUE RIDGE. Quinn T. Kiley and David J. Harbor, Dept. of Geology, Washington and Lee Univ., Lexington, Va. 24450. The surficial deposits and geomorphic processes in the James River Face Wilderness Area (JRFW) in the Jefferson National Forest, Va. form the basis of a successful land classification. The occurrence of coarse colluvium is strongly controlled by outcrops of resistant quartzite and granodiorite within the folded Blue Ridge complex. The morphology of the deposits, especially talus, varies in the degree of soil and vegetation cover, and the degree and process of erosion. Mapped units of open talus occur primarily on south and southwest facing slopes where soil and vegetation are less easily developed. These conditions, plus incision of debris flow fans, indicate the response to change of climate and climate-controlled erosional processes from periglacial to fluvially dominated. (Funded jointly by Washington & Lee University and the USFS.)

THE USE OF HYDRIC SOIL FOR WETLAND IDENTIFICATION. T.S. McDonald, Geol. and Geog. Dept., James Madison Univ., Harrisonburg, VA 22807. The concept of hydric soil is a relatively recent development, but in the past hydromorphic terms were used to describe saturated soils. Hydric soils are seen as saturated for sufficient periods during the growing season to develop anaerobic conditions in the upper horizons. Reducing or anaerobic conditions are necessary for a soil to be considered hydric and usually take about two weeks to develop. Reducing conditions are necessary for soil modifiers or indicators to develop, the most important being mottling and gleization. However, there are some problems using indicators to identify hydric soils. Hydric soil criteria are changing with time and recent additions have increased the necessary saturation time for a soil to be considered hydric. Consequently, even though it is recognized that soils are important aspects of wetland areas they are still largely overlooked in wetland identification. Priority needs at this time are clearly defined criteria for the identification of hydric soils and more data on the time factor required for hydric soils and their indicators to form. When these needs are met better classifications systems can be developed for wetland identification.

SOILS AND SEDIMENTS IN HIGH-LEVEL TERTIARY ALLUVIUM, GHOLSONVILLE, VIRGINIA. G. Richard Whittecar, Nancy K. Pontier, P.B. Corrigan*, S.W. Herman*, P.N. Henderson*, J.V. Gravette*, and P.A. Luchetti*, Dept. of Geol. Sci., Old Dominion Univ., Norfolk, Virginia 23529. The uplands along the divide between the Meherrin and the Roanoke Rivers in Brunswick County, Virginia contain irregular, broad remnants of a low-relief, deeply weathered landscape. Along that divide on VA Rt. 611 4.0 km west of Gholsonville, a 4 meter deep roadcut exposes two sedimentary units and a saprolite. Both sediment bodies are interpreted as alluvium based upon the presence of subrounded quartz pebbles and subangular quartz sand throughout. The entire profile contains abundant amounts of illuviated clay (up to 45%) that obliterate sedimentary structures. The silty saprolite and the lower alluvial unit (2.1 m thick) contain strongly developed reticulate mottling and in-situ plinthite with soil colors ranging from 10R to 5YR. The upper alluvium (1.75 m thick) contains rounded ironstone (reworked plinthite) gravel and soil colors from 5YR to 10YR. Rounding of quartz sand in the 1 and 3 phi size ranges increases somewhat upwards throughout the entire profile. A concentration of gravel (mostly ironstone) in the uppermost 30 cm may be a surficial lag recently mixed by plowing. All observations are consistant with a late Tertiary age (Miocene?) for the lower fluvial deposit that was deeply weathered and subsequently reworked by a younger (Plio-Pleistocene?) stream.

USE OF FRACTALS IN GEOLOGY. John E. Sander, Dept. of Geol. and Geog., James Madison Univ., Harrisonburg, Va. 22807. Mathematician Benoit Mandelbrot developed the fractal concept from the ideas of earlier mathematicians such as Peano and von Koch. Fractals have found application in many disciplines, including recently those of the geological sciences. For purposes of application in geology, a fractal may be defined as an object that scales in such a manner that a part of it, when magnified, is indistinguishable from the whole. Some specific applications in geology include analysis of the shape of river meanders, analysis of the trace of large faults such as the San Andreas, and measurement of the distribution of sinkholes in karst regions. The ruler method and the box-counting method are the techniques most widely used in the geological sciences to determine fractal dimension. Although the fractal dimension of a geologic object can usually be readily determined, a challenge lies in correlating this dimension with a specific geologic cause.

SAND FRACTION STUDIES OF AN UPLAND ALLUVIAL CAPPING IN APPOMATTOX COUNTY, VA. Matthew Scott & W. C. Sherwood, Dept. of Geol. and Geog., James Madison Univ., Harrisonburg, Va. 22807. Recent soils mapping in Appomattox and nearby counties has identified an extensive upland alluvial capping ranging from 0 to over 2 meters in thickness. In an attempt to determine the origin of this deposit, a total of 15 samples were taken from the alluvium and underlying residuum at three test sites. Wet sieving of the samples was carried out using a phi scale of #5, #10, #18, #35, #60, #120, and #230 sieves. All samples were found to contain high percentages of fine sand and -230 material. However, samples from the A soil horizon of the capping contained high percentages of coarse material in the phi -2 and -1 range. This coarse fraction appears to armor the capping and retard erosion. From the lab data sample mean, sorting, and skewness values were calculated. These were compared to modern beach and fluvial sands. This comparison yielded inconclusive results. Additional research involving grain rounding and heavy minerals is recommended.

ORANGEBURG SOILS AND PLIOCENE SEA LEVELS, DINWIDDIE COUNTY, VIRGINIA. G. Richard Whittecar, D.L. Rasmussen*, M.D. Zamkotowicz*, S.Y. Boyd*, A.T. Hoffmeister*, and B.C. Comstock*, Dept. of Geol. Sci., Old Dominion Univ., Norfolk, Vir. 23529. In Dinwiddie, Hanover, and Brunswick counties in southeastern Virginia, the Orangeburg soil series occurs on high level Coastal Plain terraces between the Chippenham and Broad Rock scarps, a belt mapped as the near-shore equivalent of the Pliocene Yorktown formation. The Orangeburg soil, a Typic Paleudult, contains a thick argillic subsoil that commonly has two color zones. At one 180 cm deep excavation examined in detail in Dinwiddie County, the upper "orange" (7.5YR) argillic zone contains numerous rounded pebble-size rip-up clasts of the lower "red" (2.5YR) argillic horizon, thus indicating the color break marks a disconformity that truncates a significant weathering profile. The sand fraction throughout the profile is a very uniform coarse-to-medium sand (0.25-0.28 phi, average) comprised of quartz with as much as 14% heavy minerals. Grain roundness in both the 1 and 3 phi samples decreases upwards through the profile with no discernable changes at the erosional boundary. These data suggest that a significant period of subaerial weathering occurred at this site prior to a transgression that reworked the upper portion of the soil profile. Geomorphic and pedologic features suggest that this relatively brief(?) event occurred during the Late Pliocene.

SEDIMENTS OF GUNSTON COVE, POTOMAC RIVER, VIRGINIA. Anita A. Williams, Dept. of Geography and Earth Systems Science, George Mason Univ., Fairfax, VA 22030. Gunston Cove is a tidal embayment on the Virginia side of the Potomac River. It is approximately 5 km long, 1-2 km wide, and up to 2 m deep; mean tidal range is 60 cm. The cove is underlain by Cretaceous strata of the Coastal Plain. Its two upstream drainage basins, Accotink and Pohick Creeks, have their headwaters in the Piedmont. Sediment cores of 25 to 50 cm in length have been taken in the cove. After initial description in the field, cores were sampled and analyzed for grain size, organic content, and general mineralogy; some clay minerals identified by X-Ray diffraction. Preliminary results indicate that surface sediments predominantly are mud except along the cove's southern shoreline where they are sand and at its northern shore where they are clay. Generally, the sediments coarsen with depth. These initial findings suggest that Gunston Cove contains an ancient microtidal meander zone facies that has been overlain by the present-day estuary funnel facies. This change implies a relative rise in sea level.

Materials Science

ANISOTROPIC THERMAL CONDUCTIVITY IN ORIENTED POLYMERS.
R. Edward Barker, Jr., Seth J. Wheeler, Jay R. Maddux, Dept. of Materials Sci. and Engr., Univ. of Va., Charlottesville, VA 22903-2442, and L.J. Adams, Williams International Co., Walled Lake, MI. Measurements have been made using the de Sénarmont method to determine the ratio of thermal conductivities K_{11}/K_{22} for a selection of polymers chosen to illustrate the effect of molecular orientation. The polymers discussed include polypropylene (PP) and poly(ethylene terephthalate) (P.E.T.), both as functions of elongation up to $\Delta L/L_o$=5 for PP and to 1.1 for PET. Other polymers investigated included polyparaphenylene benzobisthiazole (PBZT) and polyparaphenlylene terephthalamide (PPTA). Both are lyotropic liquid crystalline polymers which form fibrous solids with very high degrees of molecular orientation. K_{11}/K_{22} increases approximately as $(\Delta L/L_o)^{1/2}$, to 2.5 for PP at $\Delta L/L_o$=5 and to 2.3 for PET at $\Delta L/L_o$=1.1. For PBZT and PPTA K_{11}/K_{22} values are about 5.1 and 8.3, respectively, at 30°C. The data will be discussed in terms of the effects of orientation on the elastic moduli.

IN SITU HOT-STAGE STUDIES OF INTERFACE DYNAMICS DURING GROWTH AND DISSOLUTION OF θ-Al_2Cu {111} PLATES IN AN AL-CU-MG-AG ALLOY
William E. Benson* and J. M. Howe*, Department of Materials Science and Engineering, University of Virginia 22903; A. Garg*, NASA Lewis Research Center, Cleveland,OH 44135; Y. C. Chang*, Aeronautical Research Laboratory, Chung -Shan Institute of Science and Technology, Taiwan, R.O.C. Complementary conventional and high-resolution in situ hot-stage TEM studies were performed to determine the atomic mechanisms and kinetics of growth of θ-Al_2Cu plates with a {111} habit plane in an Al-Cu-Mg-Ag alloy. These studies show that the θ plates grow by a terrace-ledge-kink mechanism, where the smallest ledges and kinks are one-half of a unit-cell of the θ phase. The morphology of the plate within the habit plane is obtained by varying the density of kinks along the plate edge, and the plates change from an oval morphology near the solvus temperature to a faceted morphology at a slightly lower temperature by rapid nucleation of kinks along the (110) θ facet and adjustment of the spacings among existing kinks along the periphery. Kinetic analyses of ledge motion indicate that surface diffusion may dominate the growth kinetics of θ plates which intersect the foil surface in thin foils, while the kinetics are reasonable for a bulk diffusion process in thicker foils or when plates are wholly contained within thin foils.

FEASIBILITY OF CATHODICALLY PROTECTING EPOXY-COATED REINFORCING STEEL. D. Stephen Bognaski and S. Ray Taylor, Dept. of Materials Science, Univ. of Va., Charlottesville, Va. 22903; Gerardo G. Clemeña, Va. Transportation Res. Council. Recent studies have documented that corrosion is occurring in bridge decks which utilize epoxy-coated reinforcing bars. This is often attributed to chloride contamination from road salts or marine environments and can be both aesthetically and structurally problematic, since the reinforcement's corrosion products create internal stresses which can ultimately lead to cracking of the concrete. Work is in progress to assess cathodic protection (CP) as a means of suppressing corrosion, so to prevent further deterioration and extend the service life of decks at risk. The focus of this work is to examine the feasibility of applying CP to arrest the corrosion of epoxy-coated bars in concrete while measuring any adverse effect it may have on the steel/concrete bond strength. Experimentation has focused on test protocol and preliminary assessment of mechanical and electrochemical behavior. (Supported by the FHWA and Va. Trans. Res. Council)

ALUMINUM 3104 RIGID CONTAINER STAINING PROJECT : A CREVICE CORROSION STUDY. Brian J. Connolly, Glenn E. Stoner, John R. Scully, and R. Scott Lillard, Dept. of Materials Science and Engineering, University of Virginia, Charlottesville, VA, 22903. Annually, aluminum canstock producers lose @ two million Lbs. of their total production due to water staining. The goals of this project are as follows: 1) Development of an accelerated, quantitative staining test procedure that will replicate the industrial stain 2) Investigation of the crevice corrosion parameters (electrochemical, metallurgical, crevice solution chemistry) in order to model the mechanisms involved in the staining event. The staining event is predicated by a characteristic electrochemical wave measured at open circuit using an innovative double crevice assembly developed at the University of Virginia. Future work using this test procedure will determine the relationship between metallurgical composition and resistance to staining. Analysis and simulation of the crevice solution will help us to identify the main factor (pH, aluminum cation concentration, or salt anion concentration) contributing to the formation of the critical crevice solution which initiates the staining event. (Sponsored by: Reynolds Metals Company and The Virginia Center for Innovative Technology)

CHARACTERIZATION OF OHMIC CONTACT SOLDERS TO HIGH PERFORMANCE THERMOELECTRIC MATERIALS FOR COOLING APPLICATIONS. M. H. Ettenberg, W. A. Jesser, F.D. Rosi, Dept. of Materials Science and Engineering, University of Virginia, Charlottesville, Va. 22903. Modern refrigerants are being phased out due to their toxicity to the environment and many alternatives are being studied including thermoelectric materials. Even though thermoelectric materials are not as efficient as Freon-12, they have many advantages. Thermoelectric materials of the pseudo-ternary Bi_2Te_3-Sb_2Te_3-Sb_2Se_3 have been found to be the best for room temperature refrigeration, but they do not provide as much cooling (delta T) as their figure of merit would predict. The discrepancy between theoretical and measured delta T may be due to the solders that are presently used. To make these devices as efficient as possible solders that provide a small ohmic contact resistance need to be developed. A four probe contact resistance testing station was built. Using this station two methods of obtaining the data were developed, the extrapolation and the step technique. The step technique was found to be a more reliable and accurate method to measure the contact resistance. Using this technique several lead-free solders are being studied electrically. The solders are also being investigated metallographically with a Scanning Electron Microscope (SEM). (Supported by Naval Surface Warfare Center Carderock Division, Detachment Annapolis)

HYDROGEN EFFECTS IN METASTABLE ß-TITANIUM ALLOYS. Michelle A. Gaudett & John R. Scully, Dept. of Materials Science and Engineering, Univ. of Va., Charlottesville, VA, 22903. The effects of electrochemically charged hydrogen on the room temperature mechanical properties of Beta-C titanium (Ti-3Al-8V-6Cr-4Mo-4Zr, wt%) will be studied in order to define the relationships between the fracture process zone hydrogen concentration, trapping, and hydrogen-metal interactions and the resulting mechanical properties. The effects of heat treatment and microstructure on the resistance to hydrogen embrittlement (HE) will be investigated using a procedure that decouples hydrogen effects from other aqueous embrittlement mechanisms. A finite element analysis will be applied to pre-notched tensile bars that have been charged to various hydrogen concentrations and tested in air, in order to quantify the degree of HE in terms of the reduction in the maximum longitudinal stress and the plastic strain at maximum load. In addition, fracture toughness experiments will be performed on hydrogen precharged material in air to determine the threshold stress intensity for crack growth. The microstructural feature(s) that control the fracture process will be determined by establishing correlations between hydrogen concentration and trapping, microstructure and the degree of embrittlement. The damage observed will be rationalized in terms of existing or new HE models. Comparisons will be made to other ß-titanium alloys such as TIMETAL 21S and TIMETAL 15-3 to evaluate the effect of alloying additions on HE resistance. (Supported by the Office of Naval Research and the Virginia Center for Electrochemical Sciences and Engineering at the Univ. of Va.)

TRACE ELEMENT EFFECTS ON PRECIPITATION AND MECHANICAL PROPERTIES IN AN AL-CU-LI ALLOY. D.L. Gilmore and E.A. Starke, Jr., Materials Science Dept., Univ. of Va., Charlottesville, VA 22903. Trace element additions can accelerate age-hardening in aluminum alloys. By favoring one precipitate system over another, these additions can also effect the yield anisotropy of the material. Anisotropy may also be reduced by substitution of an alloying addition for a pre-aging stretch (T8 heat treatment). Conventional transmission electron microscopy, high-resolution electron microscopy, x-ray texture measurements, and tensile yield tests have been performed in order to discover more about the mechanisms by which indium and magnesium affect precipitation and how this subsequently affects yield anisotropy in aluminum sheet. Findings suggest that both θ' and T1 precipitates are affected, but not equally. The benefits of indium may be superceded by those of magnesium (Supported by the Office of Naval Research and the National Science Foundation.)

WRITING ACROSS THE CURRICULUM IN THE PHYSICAL SCIENCES AND ENGINEERING. Robert W. Hendricks and Eric C. Pappas, Materials Science and Engineering Department, Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061-0237. We describe the development and implementation of an integrated program for engineering communications in the Materials Science and Engineering (MSE) Department and its extension into a writing across the curriculum program being co-developed by faculty from six departments, two in the physical sciences and four in engineering, at Virginia Tech. The on-going MSE program integrates a significant writing and communications component into eight required courses distributed over three years, and reaches approximately 90 students each semester. It starts with the students' first materials course in the fall semester of their sophomore year and culminates in the Senior Design Project. Limited results, based on two semesters of testing, indicate significant student participation and generally favorable response, as well as excellent faculty response. The broader WAC program, recently approved by SCHEV under the Funds for Excellence program, has several specific program objectives including 1) improving student writing and communications skills in order to enhance their post-graduation marketability, and on-the-job satisfaction and productivity; 2) creating a permanent writing and communications organizational structure that will encourage superior writing and communications skills among science and engineering students; 3) creating an organizational structure that will help faculty integrate writing and communications skills into discipline-specific settings; and 4) serving as a model for other university departments wishing to integrate writing and communications into their curriculum. The paper will report on our experiences to date and describe our anticipated future developments.

INVESTIGATION OF THE MECHANICAL PROPERTIES OF THE MACRO-INTERFACE IN SELECTIVELY REINFORCED ALUMINUM CASTINGS. Michael J. O'Connor*, Dept. of Materials Science, University of Virginia, Charlottesville, Va. 22903. The ring groove areas of cast Al-12Si pistons can be reinforced with SiC whiskers to provide local high temperature strength and wear resistance. Due to the difference in thermal expansion between the reinforced region and the unreinforced alloy, thermal residual stresses can form at the interface between them when the piston experiences a temperature change relative to some stress-free temperature. Thermal cycling will therefore produce cyclic residual stress at this interface, possibly causing fatigue. To determine if fatigue will occur, the strength of the macro-interface in two alloy-composite systems was measured before and after thermal cycling. It was found that accumulated alloy precipitates or other material at the macro-interface can influence its initial strength. No evidence of thermal fatigue with thermal cycling was found. However, it was determined that the aging behavior of the alloy plays a significant role in defining the strength of the macro-interface with thermal exposure. (Funding provided by General Motors Corporation)

SUSCEPTIBILITY OF STAINLESS STEEL AND NICKEL BASED ALLOYS TO MICROBIALLY INFLUENCED CORROSION(MIC). T.A. Petersen, D.G. Enos & S.R. Taylor, Dept of Materials Science, Univ. of Va., Charlottesville, Va. 22903. Industries which use natural waters for cooling have identified MIC as a problem. Weldments found in cooling water systems have been reported to have pitting corrosion. The welding process causes changes in the metallurgy of the alloy which effects surface texture, surface oxidation, elemental segregation and the formation of precipitates and inclusions. These changes enhance bacterial attachment and therefore contribute to MIC. One species which has been reported to facilitate MIC are the sulfate reducing bacteria. Proposed theories as to the mechanism by which sulfate reducers influence corrosion are: cathodic depolarization, attack by sulfides and by the formation of corrosive phosphorous containing metabolites. Material selection is one way of addressing MIC found in cooling water systems. Materials which contain molybdenum(Mo) have been reported to be less susceptible to corrosion. In this study eight alloys, with varying concentrations of Mo, were welded and exposed to natural water for nine months. Electrochemical techniques were used to evaluate corrosion resistance and to monitor bacterial activity. Previous work shows decreasing corrosion resistance for the following alloys: unwelded alloy 625 > welded alloy 625 > 317L > 316L > 308 > 304 > A36. Based on data obtained from a previous study a 6% Mo alloy has been added to the current test matrix and edge preparation has been modified for alloy 625 clad.

FORCES ON PARTIAL DISLOCATION PAIRS IN EPITAXIAL LAYERS. Chimin H. Simpson and Dr. William A. Jesser, Dept. of Materials Science and Engineering, University of Virginia, Charlottesville, VA 22903 . In epitaxial layers, driving force for dislocation movement is due to misfit strain and varies with the substrate orientations. In this work, driving forces on twelve <112> {1 1 1} partial dislocation pairs versus various substrate orientations are calculated by Peach-Koehler equation. The Peierls force and line tension are considered as retarding forces. When two partial dislocations move in the same direction, stacking fault energy will act as the retarding force for the leading partial dislocation, but as a pulling force for the tailing dislocation. If the excess force on the leading partial dislocation is much greater than that on the tailing dislocation, widely separated stacking faults will be observed in the epitaxial layers. Selecting the substrate orientations with the least stacking faults and threading dislocations is the objective of this work. Both extrinsic and intrinsic stacking faults are addressed in epitaxial layers under tensile and compressive stress biaxial stresses are also contemplated. Under this conduction, the optimum orientation would be around {012} orientation.

MODELLING CREVICE CORROSION. Kevin C. Stewart and Robert G. Kelly, Department of Materials Science and Engineering, University of Virginia, Charlottesville, Va 22903. The goal of this research is to gain a greater understanding of crevice corrosion by combining modelling and experimental determination of the crevice environment during corrosion. Mathematical modelling of the generation and mass transport of chemical species is aided by the use of object-oriented design (OOD). OOD naturally leads to code which is modular, and thus easy to modify, and abstracts model parameters away from programming details. This work expands on previous modelling efforts by the use of OOD and in its implementation of boundary conditions. Experimental measurements of the crevice environment will be made by freezing the crevice solution and analyzing samples of it by capillary electrophoresis (CE). CE is able to detect concentrations as low as 2 mM in sample volumes as small as 30 nl. The ultimate goal of this research is to create functional model of crevice corrosion to allow evaluation of different theories of crevicing, permit separation of effects, and serve as a vehicle for "what-if" computer experimentation.

MAPPING OF COATING DEFECTS USING LOCAL ELECTROCHEMICAL METHODS. Markus W. Wittmann, and S. Ray Taylor, Department of Materials Science and Engineering, University of Virginia, Charlottesville, VA. 22903. Coating failure is often a local event occurring at a physical or chemical heterogeneity. Failure may be a result of a bad coating, or it may result from coating application, curing techniques, the substrate, or its preparation. The ability to map local electrochemical variations would aid in determining the mechanism of coating failure, and its prevention. The objective of this study is to use local electrochemical impedance spectroscopy (LEIS) for the evaluation of local coating defects. Local impedance measurements are determined from a ratio of applied voltage and local current density determined from potential gradients at the surface. This technique was used to scan various coating defects. These include pores, thinned regions, underfilm deposits, and chemical heterogeneities.

Medical Science

ANANDAMIDE STRUCTURE-ACTIVITY RELATIONSHIPS. L. Adams, R. Razdan and B. Martin. Department of Pharmacology and Toxicology, Medical College of Virginia, Richmond, USA and Organix, Inc., Woburn, MA. Recent evidence implicates anandamide as the endogenous ligand for the cannabinoid receptor. The purpose of this study was to determine the structural requirements for anandamide's interaction with the cannabinoid receptor in the presence of phenylmethylsulfonyl fluoride (PMSF), an enzyme inhibitor. The ability of anandamide and analogs to displace $[^3H]$-CP-55,940, a potent synthetic cannabinoid agonist, was determined by a filtration assay. A Scatchard analysis of $[^3H]$-CP-55,940 binding resulted in a K_d of 590 ± 90 pM and a B_{max} of 344 ± 22 pM. Displacement curves for anandamide in the presence of PMSF produced a K_i of 67 nM ± 8 nM; without PMSF the K_i increased to 5400 ± 1600 nM. The structure-activity relationship indicated the importance of the double bond structure, with saturation of all double bonds except at carbon 11 resulting in inactivation (K_i > 10,000 nM). Increasing the length of the N-substituent by one or two carbons decreased receptor binding affinity. Also, the hydroxyl group was an important part of the structure of anandamide. Substitution of the hydroxyl group with a fluorine atom increased affinity (K_i = 7.0 ± 0.9 nM), but only in the presence of PMSF. Hydroxyl substitution with a benzenesulfanilamide group did not significantly alter affinity; yet, addition of a methoxy group to the same position decreased affinity (K_i = 1400 ± 230 nM). Certain structural modifications allowed the analogs to retain affinity without the addition of PMSF, such as methylations at carbon adjacent to the N. These results reveal a structure-activity relationship of anandamide which is consistent with a drug-receptor interaction. (Supported by DA-07027, DA-03672 and DA-05488).

REGULATION OF SUPPRESSOR MACROPHAGE NITRIC OXIDE AND TUMOR NECROSIS FACTOR-α PRODUCTION: ROLE OF FIBROSARCOMA-DERIVED INHIBITORY MOLECULES. David G. Alleva and Klaus D. Elgert, Dept. Biol., Va Polytechnic Inst. & State Univ., Blacksburg, Va 24061-0406. *In vitro*-activated macrophages ($M\phi$) co-express cytotoxicity for tumor cells and suppression of lymphocyte proliferation. These $M\phi$ functions are increased during tumor growth and are mediated by soluble suppressor molecules. Because $M\phi$-derived nitric oxide (NO) and tumor necrosis factor-α (TNF-α) mediate both cytotoxicity and suppression, we determined if tumor growth increases $M\phi$-mediated suppression of T cell proliferation by increasing $M\phi$ NO and TNF-α synthesis. Activated tumor-bearing host (TBH) $M\phi$ produced more NO and TNF-α than normal host (NH) $M\phi$. This tumor-induced increase in $M\phi$ NO and TNF-α synthesis mediated suppression of alloantigen-driven T-cell proliferation because treatment with N^Gmonomethly-L-arginine or anti-TNF-α antibody blocked TBH $M\phi$-mediated suppression. TNF-α did not directly suppress T cells, but it induced $M\phi$ NO synthesis which down-regulated proliferation. When nontumor-infiltrating peritoneal $M\phi$ were cultured with tumor cell supernatants, $M\phi$ synthesis of NO and TNF-α was strongly down-regulated. The tumor-derived molecules responsible for this inhibition were interleukin-10, transforming growth factor-β, and prostaglandin E_2 because the fibrosarcoma cells produced significant levels of these molecules, recombinant forms of these molecules suppressed NO and TNF-α synthesis, and antibody-mediated absorption of these cytokines from tumor cell supernatants restored NO and TNF-α synthesis. Collectively, these results suggest that tumor growth favors $M\phi$ suppressor activity mediated by cytotoxic molecules by increasing $M\phi$ synthesis NO and TNF-α in tumor distal locations and down-regulating their local synthesis.

MODULATION OF VOLTAGE-SENSITIVE CA^{++} CHANNELS IN MORPHINE-TOLERANT MICE. Marissa A. Bernstein, Charity E. Thomas, & Sandra P. Welch. Dept. of Pharmacology & Toxicology, Med. Col. of Va., Richmond, Va. 23298. Chronic morphine treatment has been shown to increase both Ca^{++} content as well as K^+-stimulated Ca^{++} uptake in synaptosomes, suggesting a possible increase in the number of voltage-sensitive Ca^{++} channels concurrent with the development of tolerance. However, studies to date have produced conflicting results. In this study, regulation of "L-type" Ca^{++} channels by chronic morphine exposure in mouse brain and spinal cord was determined by binding of [^{3}H]nitrendipine. Mice were treated for 5-7 days with subcutaneously implanted placebo or morphine pellets. Tolerance was determined by testing for antinociception using the tailflick procedure following an 8 mg/kg sc dose of morphine. P2 pellets were resuspended in 50 mM Tris buffer (pH 7.4) to a final protein concentration of 0.8-1.2 mg/ml for brain, 1.2-2.4 mg/ml for cord. Tissue was frozen and stored at -70 ^oC until day of assay. Thawed tissue was incubated with labelled drug, using nifedipine to determine nonspecific binding, for 90 minutes at room temperature in the dark, with a total volume of 2 ml per tube. In untreated whole brain, K_D = 62.8 pM and B_{max} = 172.3 fmol mg^{-1} protein. In the untreated spinal cord, K_D = 145.8 pM and B_{max} = 49.5 fmol mg^{-1} protein. Nitrendipine was competitively displaced with high affinity by BAYK 8644. The results showed no significant difference in binding between fresh and frozen tissue, nor among naive, placebo-treated, and morphine-tolerant mice for either brain or spinal cord. The involvement of "N-type" Ca^{++} channels is currently being investigated by binding of [^{125}I]-ω-conotoxin MVIIA in mouse brain and spinal cord. (Supported by NIDA grants DA06031 and DA07027.)

THE EFFECTS OF PRENATAL STRESS ON FREE CALCIUM CONTENT IN THE SERA OF RATS. B. C. Billack, K. Devine*, & C. H. Kinsley. Department of Psychology, University of Richmond, VA 23173. Recent studies have shown that exposure to various stressors results in elevated levels of free calcium (FC) in the sera of rats. These data suggest that activation of stress-related systems may have an impact on this realm of regulatory function, insofar as adult exposure to stress is concerned. What of stress exposure on developing systems? In the present study, the effect of prenatal stress (exposure to heat, light, and restraint three times daily on days 14-21 of pregnancy) on FC levels in sera of juvenile rat offspring was examined. Pregnant females were stressed as above; controls were left undisturbed. At birth, litters were culled to 10 pups. At 45 days of age trunk serum samples were collected from both stressed and control offspring. A calcium ion selective electrode was used to determine FC concentration. A sex difference in FC was observed, with males having higher FC levels than females. Preliminary data demonstrated no effect of prenatal stress on FC levels. (Supported by University of Richmond research funds.)

USE OF IMAGE ANALYSIS AND VIDEO MICROSCOPY TO DETERMINE THE EVOLUTION OF INTRALUMINAL DISTRIBUTIONS OF HEMOGLOBIN CONCENTRATION AND OXYGEN SATURATION IN ARTERIOLES OF THE HAMSTER RETRACTOR MUSCLE. Daniel W. David & Roland N. Pittman, Dept. of Physiol., Va. Commonwealth Univ., Richmond, Va. 23298-0551. The observed diffusion of oxygen from arterioles is an order of magnitude higher than expected (Popel et al., AJP 256:H921, 1989). The calculation of oxygen diffusion requires estimates of oxygen saturation (SO_2) and hemoglobin concentration ([Hb]) in the blood flowing through the arterioles. The values previously used for SO_2 and [Hb] were obtained from center-line measurements, and based on the assumption that the luminal distributions of SO_2 and [Hb] were uniform. However, Ellsworth and Pittman observed that the profiles were indeed not uniform (Ellsworth et al., AJP 251:H869, 1986), and we are exploring the possibility that the non-uniform nature of the distributions is a major contributor to the order of magnitude discrepancy. In an effort to reduce the discrepancy between the experimental observations and the theoretical model, Parthasarathi obtained full diametric light intensity measurements using image analysis of video-taped arterioles to improve the estimates of SO_2 and [Hb] (Parthasarathi, VCU/MCV M.S. Thesis, 1993). However, a low signal-to-noise ratio and geometric distortions in the recorded image made the analysis difficult. The current work describes modifications made to the video microscopy setup and analytical methods that will lead to more reliable determinations of SO_2 and [Hb] distributions. (Supported by NIH Grant HL18292)

IMMUNOSUPPRESION IN B6C3F1 MICE BY DERMAL EXPOSURE TO BENZO(a)PYRENE. C. L. Deal III, L. F. Butterworth*, D.J Mason*, and K.L. White Jr., Dept of Pharm. and Tox., Med. Col. of Va/VCU, Richmond, VA. 23298 The immunosuppressive effects of benzo(a)pyrene, [B(a)P], the prototypical polycyclic aromatic hydrocarbon, have been shown by many investigators. However, much of this work has utilized subcutaneous injection as the route of administration. Consistent with human environmental exposure, we examined the effects of B(a)P on the humoral immune response via the dermal route of administration. The objective of these studies was to determine if dermal exposure to B(a)P was capable of suppressing the IgM and IgG antibody responses to the T-dependent antigen, sheep erythrocytes (sRBC). The lower backs of female B6C3F1 mice were shaved and exposed for 14 consecutive days to B(a)P at doses of 5, 20, and 40 mg/kg or vehicle (4:1; acetone:olive oil). Using an Enzyme Linked ImmunoSorbent Assay (ELISA), a statistically significant, dose-dependent suppression was observed in serum antibody levels (titers). The serum IgM antibody titers evaluated 4 days after the primary injection of sRBC (day 15 of the study), of animals treated with 5, 20 and 40 mg/kg were 63, 40 and 31 percent of control, respectively. IgG titers, evaluated 5 days after secondary injection of sRBC (day 30 of the study), were 55, 33 and 29 percent of control, respectively. In most of the previous *in vivo* studies of humoral immunity, primary splenocytes were used for enumeration of antibody forming cells in the plaque assay necessitating separate groups of animals to evaluate the IgM and IgG response at each time point studied. In our studies, we were able to evaluate serum titers of both IgM and IgG antibodies at multiple time points in the same animals. The ELISA methodology allows cost and time-effective determination of humoral response changes in IgM as well as in IgG. Additionally by evaluating the ELISA response to a different T-dependent antigen, the recovery from immunotoxic compounds can be carried out in the same group of animals. Supported by NIEHS contract ES 05288.

MORPHOMETRIC POST-NATAL DEVELOPMENT OF THE MOUSE EPIDIDYMIS. Peter A. Good and Roman J. Miller, Eastern Mennonite College, Harrisonburg, Va. 22801. To determine significant epididymal developmental patterns, the maturation of the caput/corpus epididymis was examined in mice killed at postnatal days(d) of 20, 30, 40, 50, 60, 90, and 120, using light microscopy, DNA and RNA assays, and sperm counts from homogenized epididymides. Tubule diameter (TD), tubule wall width (TW), and epididymal wet weight (WW) increased most between d20 and d40 (TD: 62%; TW: 50%; WW: 350%). During the same time period, the RNA/DNA ratio increased 28%, after which it decreased sharply by 40% between d40 and d60. Both tubular wall(TW) and extra tubular tissue (ET) grew faster between d20 and d30 (TW: 590 µg/d; ET: 400 µg/d) than between d90 and d120 (TW: 143 µg/d; ET: 53 µg/d). Total lumen volume increased 275 µl/d between d20 and d60 after which lumen volume reached a plateau. Epididymal sperm were first seen histologically at d40. While homogenized sperm counts peaked at d90, histological sperm concentration reached a maximal level at d60 (5.1 mg/organ), which was not statistically different from d90. DNA content correspondingly increased 75% between d50 and d60. Thus sexual maturity in mice, as indicated by maximal sperm levels in the epididymis, occurred between d60 and d90. Both histological analysis and homogenized sperm counts showed that sperm production declined significantly from peak levels by d120.

MORPHOMETRIC CHARACTERISTICS OF THE MOUSE TESTIS DURING POSTNATAL DEVELOPMENT PERIODS. Mark R. Grimaldi and Roman J. Miller. Eastern Mennonite Col., Harrisonburg, Va. 22801. The postnatal histology of the Swiss-Webster mouse testis was studied to determine significant developmental events. Using light microscopy, morphometric analysis was done at day (d) 20, 30, 40, 50, 60, 90, and 120. The parameters of study included seminiferous tubule diameter (TD), tubule wall thickness (TT), and volume percent of tubule wall (TW), total lumen (TL), empty lumen (EL), lumen sperm (LS), and extra-tubular tissue (ET). TW increased from 13% on d20 to 68% on d120. TL peaked at 26% on d50 and decreased to 24% by d120. EL increased steadily from 2% on d20 to 16% on d120. LS was first appearent on d30, peaked at 12% on d50, and decreased to 7% by day 120. ET peaked at d60 and then decreased slightly by d120. TD increased from 112µm on d20 to 185µm on d50 and then remained relatively constant. TT increased from 42µm on d20 to 69µm on d60 and then dropped to 63µm by d120. Based on the the amount of growth and the appearence of sperm, the testis becomes functional at approximately d30.

ROLE OF CYTOTOXIC T CELLS IN THE INDUCTION OF VASCULAR LEAK SYNDROME (VLS) DURING CANCER IMMUNOTHERAPY. Denise M. Hammond and Prakash S. Nagarkatti, Dept. of Biology Virginia Polytechnic Inst. and State Univ., Blacksburg, Virginia 24061. Immunotherapy of cancer with IL-2 or a combination of LAK (Lymphokine Activated Killer) cells and IL-2 has met with varying degrees of success. One of the major problems associated with such an approach is severe toxicity clinically characterized by development of vascular leak syndrome (VLS). The mechanism of increased vascular permeability causing VLS not clearly understood. In the current study we investigated the role of cytotoxic T lymphocytes (CTL) in the induction of VLS. The CTL clone, PE-9 used in this study was $CD8^+$ $\alpha\beta TCR^+$ and was specific to a tumor designated LSA. When rIL-2 (~130,000 U/mouse) was injected twice daily for 5 days into normal C57BL/6 mice, they exhibited significant VLS as evidenced by extravasation of ^{125}I-BSA in the lungs, liver, and spleen. IL-2 failed to induce VLS in irradiated C57BL/6 mice thereby suggesting that the VLS was triggered by a radiosensitive cell. Interestingly, administration of CTL clone and IL-2, but not the CTL clone or IL-2 alone into irradiated mice triggered VLS. Our data therefore suggests that CTL when activated *in vivo* can induce VLS *in vivo* The CTL clone, upon culture with IL-2 could also mediate lysis of endothelial cells *in vitro*. Such lysis was TCR-independent and MHC-unrestricted. Together, our data demonstrated that CTL when activated with high concentrations of IL-2 may exhibit MHC-unrestricted killing and this may lead to killing of endothelial cells via certain adhesion molecules, such as, CD44 and $gp90^{MEL-14}$ and such a mechanism may inturn lead to induction of VLS *in vivo*.

THE TRANSFORMATION AND MAINTENANCE OF T CELL LYMPHOMAS AS A RESULT OF IL-2 AUTOCRINE STIMULATION. Mona Hassuneh and Mitzi Nagarkatti. Dept. of Biology, Va. Polytechnic Inst.& State Univ., Blacksburg, VA 20461. The development of neoplasia requires the simultaneous presence of a number of molecular perturbations. Autocrine growth factor constitutive production is one such perturbation. In recent work we investigated the spontaneous transformation of a couple of T cell clones during routine cell culture. We demonstrated that the transformed clones were exclusively dependent on IL-2 autocrine stimulation in their *in vitro* as well as *in vivo* growth. This was evidenced by the fact that such T cells constitutively expressed IL-2 gene and the cells were inhibited from growing in the presence of mAbs against IL-2, IL-2R and IL-2 antisense oligonucleotides. During that work several T-cell lymphomas that spontaneously originate *in vivo* such as LSA and EL-4 were also tested. Interestingly, LSA cell line was inhibited from *in vitro* proliferation in the presence of mAb directed against IL-2 and IL-2R. Also, treating this lymphoma cell line with cyclosporin A inhibited their *in vitro* growth in a dose dependent manner. These data show that the *in vitro* growth of these tumors is maintained through the continuous production and responsiveness to IL-2. Furthermore, LSA demonstrated the constitutive expression of mRNA for IL-2 and IL-2R β-chain (p75). Together our Studies suggest that T cell lymphomas that originate spontaneously *in vivo* can be dependent on IL-2 as an autocrine growth factor and that such T cell lymphomas can be treated using IL-2 antagonists.

THE ROLE OF PRENATAL STRESS ON THE ANTERIOR COMMISSURE OF MALES. 1)Hendree Jones, 1) *Lori Keyser, 1) *Claudia Gonzalez, 1) *Mike Ruscio, 1) Ricky Rowe, 2) Kelly G. Lambert & 1) Craig H. Kinsley, 1) Dept. of Psych., Univ., of Richmond, Richmond, Va. 23173. 2) Dept., of Psych., Randolph-Macon Coll., Ashland, Va. 23005.The effects of prenatal stress (light/restraint) on the development of the anterior commissure (AC) were investigated. The AC is known to be a sexually dimorphic structure of the brain not directly involved in reproductive behavior, but unlike hypothalamic structures and nuclei, little is known about its development. The present work examines the factors, sex and stress, known to influence other brain areas. Pregnant rats were assigned to prenatal treatment and control groups. The treatment group was stressed thrice daily for thirty minutes using light/restraint during the third trimester (day 14-21). Control dams remained undisturbed. Male and female offspring were killed between days 90-100 of life. The brain was coronally sectioned and stained with thionin. The AC of each animal was measured for area (mm^2)and volume (mm^3). Results indicated control females had a greater AC area and volume relative to control males. Prenatally stressed males had a significantly greater area and volume of AC relative to control males. The neuroanatomical differences support the hypothesis that factors operating in the prenatal environment affect sexually dimorphic structures in the brain not directly involved in reproduction.

THE EFFECTS OF ANGIOTENSIN II AND FIBROBLAST GROWTH FACTOR-ß ON DEVELOPMENT OF PERIPHERAL COLLATERAL ARTERIES. Treacy D. Jones, Lara E. Storms, and Patricia B. Williams, Dept. of Pharmacology, Eastern Virginia Medical School, Norfolk, VA 23501.

Collateral arterial growth results from hypertrophy or hyperplasia of existing vessels as a means of restoring peripheral blood flow to chronically ischemic tissues. Basic fibroblast growth factor-ß (bFGF), angiotensin II (AII), and captopril have been shown to affect vascularization in tissues deprived of normal blood flow. To induce collateral development, left femoral arteries in Wistar rats were ligated. bFGF (24 ng/d), AII (288 mg/Kg/d), or captopril (6.5 mg/K/d) was administered by osmotic pump for 4 wk. Collateral arteries were visualized by Microfil perfusion, photographed, and measured by digital planimetry. bFGF and AII had an angiogenic effect in both limbs. However, the effects of bFGF were more prominent in the ischemic limb compared to the normal limb. Captopril had minimal effect upon vessel growth and development. In conclusion, this model appears to be appropriate for the study of peripheral collateralization. (Supported in part by the American Heart Association/Virginia Affiliate).

CARDIOVASCULAR EFFECTS OF ANANDAMIDE IN ANESTHETIZED RATS. Kristy D. Lake, Karoly Varga* and George Kunos*. Dept. of Pharmacology & Toxicology, Virginia Commonwealth Univ., Richmond, VA 23298. Previous research has shown that cannabinoids can affect blood pressure (BP) and heart rate (HR) in experimental animals and in humans. We examined whether the recently discovered endogenous cannabinoid ligand, anandamide (AN), also has cardiovascular effects. In urethane-anesthetized rats AN, 0.2-20 mg/kg iv., caused complex, dose-dependent and highly reproducible changes in BP and HR. The response to AN consisted of 3 phases: (1) initial acute bradycardia associated with apnea and hypotension, followed by a (2) brief pressor component and (3) a delayed hypotension lasting 5-10 min. The initial bradycardia and hypotension could be prevented by methylatropine, 2 mg/kg iv., or bilateral vagotomy. The α-adrenergic antagonist, phentolamine, reduced BP but did not affect the pressor component of the response to AN. The more prolonged hypotensive phase was inhibited by indomethacin. During this third phase, the pressor response to phenylephrine was markedly attenuated. We conclude that AN potently affects the cardiovascular system: the initial bradycardic phase is probably due to central vagal activation. The secondary pressor component is not sympathetically mediated, while the more prolonged hypotensive phase may be related to reduced sympathetic vasoconstriction associated with decreased sensitivity of vascular α-receptors. The ability of indomethacin to block the hypotensive phase implicates the arachidonic acid pathway in this action of AN. Further characterization of the mechansim of action of AN is underway.

TUMOR GROWTH INCREASES T-CELL AND MACROPHAGE SENSITIVITY TO TRANSFORMING GROWTH FACTOR-BETA. Christopher A. Learn, Thomas M. Walker, and Klaus D. Elgert, Dept. of Biol., Va. Polytechnic Inst. & State Univ., Blacksburg, Va 24061-0406. Transforming growth factor-beta (TGF-β) is a downregulatory cytokine that restricts immune cell proliferation during immunogenic challenge. We and others show that several tumor types synthesize TGF-β, and that tumor-derived TGF-β may contribute to decreased immune responsiveness in tumor-bearing hosts (TBH). The objective of our investigation was to determine if tumor growth increases the sensitivity of two important immune cell populations (T cells and macrophages [Mϕ]) to TGF-β. T-cell sensitivity was assessed by comparing normal host (NH) and TBH T-cell proliferation in the absence or presence of TGF-β. Mϕ sensitivity was assessed by comparing NH and TBH Mϕ GM-CSF synthesis in the absence or presence of TGF-β. TBH T-cell proliferation in response to several activation signals was suppressed by TGF-β. TBH Mϕ synthesis of granulocyte-macrophage colony-stimulating factor (GM-CSF) was significantly suppressed by TGF-β. Collectively, the current data suggest that tumor-derived TGF-β contributes to the rapid degeneration and suppression of immune cell reactivity during tumor growth. Future studies will determine if tumor growth increases immune cell synthesis of TGF-β.

ANGLE INDEPENDENT DOPPLER COLOR IMAGING TECHNIQUE. Danhui Liu, Cai-Ting Fu*, & Ding-Yu Fei*, Dept. of Biomed. Eng., Va. Commonwealth Univ., Richmond,Va.23298. Doppler Color imaging is now widely used in ultrasound techniques as a mean of diagnosis and monitoring in surgery, mainly involved in the cardiovascular system. However, the image obtained from a commercially available color Doppler flow imaging system has been proved to be angle dependent, i.e., the velocity shown on the machine is not the true velocity but a component of true velocity on the direction of the ultrasound beam. These unfaithful images would give some misleading information. Recently, a computer system has been set up to obtain angle independent Doppler color images by image processing method. The basic principle of the processing is to obtain the angle independent velocity amplitudes and angles in a flow field from three images acquired with three different beam steering directions. The images are taken by an Acuson 128 ultrasound imaging system using linear array transducer. Data processing is performed by a computer and the results can be presented in different formats. Experiments have been conducted both in steady flow and pulsatile flow models and in large vessels of the vascular system. The reconstructed color flow maps, not affected by the Doppler angle, show the real flow patterns and velocity distribution in vitro and in vivo. This may provide more accurate and intuitive information for the local physiological and pathological events. Significance of this technique may be expected in hemodynamics and diagnosis of vascular abnormalities.

THE EFFECT OF JOINT CURVATURE ON THE MECHANICAL PROPERTIES OF ARTICULAR CARTILAGE. N.Mukherjee and J.S.Wayne*, Ph.D., Va. Commonwealth Univ., Richmond, Va 23298-0694. The hydrated and viscoelastic nature of articular cartilage (A.C.) enables it to aid in lubrication and load distribution in diarthrodial joints. The u-p finite element method modelled the A.C. as consisting of two phases - a solid phase of collagen fibrils and proteoglycan aggregates and a fluid phase of interstitial water. It used solid displacement (u) and fluid pressure (p) as the nodal parameters. This study investigated the effect of joint curvature on the mechanical properties of A.C. as obtained from its response to indentation loading. A permeable indentor of radius 0.75 mm was suddenly pressed onto the cartilage surface of rabbit medial and lateral femoral condyles (The A.C. was still attached to the subchondral bone.) with a load of 10 grams and the ensuing creep was studied. To model the indentation geometry, a mesh consisting of 338 axially symmetric elements and 382 nodes was used. The mechanical properties determined for the A.C. were aggregate modulus, Poisson's ratio and permeability. Creep data from experiments were curve fit with the u-p model (modified to incorporate a non-linear curve fitting routine) using curved or flat surface geometries for six sets of creep data. The results show that different values of all three properties were obtained in all cases when the curvature of the joint was accounted for. Only the Poisson's ratio was significantly overestimated ($p < 0.05$) by the assumption of a flat surface when interspecimen variability was taken into account.

APPLICATION OF 5-BROMOMETHYL FLUORESCEIN (5-BMF) FOR DERIVATIZATION OF CARBOXYLIC ACIDS SUITABLE FOR LASER-INDUCED FLUORESCENCE DETECTION Partha.S. Mukherjee & H.Thomas Karnes, Dep.t of Pharmacy & Pharmaceutics,Virginia Commonwealth University, Richmond, VA 23298-0533. The goal of this work is to produce optimally excited fluorescent derivatives of carboxyl containing analytes for argon ion laser excitation using 5-BMF as the reagent. The model analytes chosen were (a) benzoic acid, (b) prostaglandin E_2 (PGE_2) and (c) palmitic acid. The reagent failed to conjugate benzoic acid but was found to be a potential candidate for PGE_2. 5-BMF was refluxed with palmitic acid at 70°C for 35 min. in the presence of K_2CO_3 and 18-crown-6 as the catalyst. Under the HPLC conditions employed, two peaks eluted at 16.7 and 23.7 min and were due to apparent conjugates of palmitic acid as confirmed by carrying out elimination reactions. The peaks retained 87% and 23% of the original fluorescence upon derivatization.The yield of the conjugate eluting at 16.7 min was maximized by sequential optimization of several reaction variables. The excitation and emission maximum of the conjugate were 501 and 523 nm respectively and showed potential for quantitation using the intense 488.0 nm argon ion emission line. A limit of detection of 1.04 pmole on-column was established using conventional fluorescence for the conjugated palmitic acid. Work is on-going to evaluate the detectability of the conjugate using laser-induced fluorescence.

DRUG MEDIATED IMMUNOMODULATION IS NECESSARY IN THE CURE OF CANCER. Eileen Murray and Mitzi Nagarkatti, Biol. Dept. VPI & SU, Blacksburg, VA 24060. Previously we showed a correlation between the immunosuppressive properties and the ability of nitrosoureas to cure C57BL/6 mice bearing a syngeneic LSA tumor (TBM). We tested our hypothesis with two classes of anti-cancer drugs, 5-fluorouracil (5-FU) and cyclophosphamide (CY). First, we checked the efficacy of these drugs in TBM and found that neither proved effective in our tumor model. Next, we evaluated the in vitro and in vivo tumoricidal activity. CY lacked in vitro tumor toxicity, but both drugs demonstrated a dose dependent tumor toxicity in vivo. Thus, indicating that the LSA lymphoma is not CY nor 5-FU resistant. Finally, we administered various doses of these drugs to normal C57BL/6 mice and examined the T and B-cell response to mitogens. CY proved to be highly immunosuppressive while 5-FU was not. Thus, 5-FU fits our hypothesis that anti-cancer agents which cure TBM should be immunomodulatory. However, CY did suppress T and B-cell activation but failed to cure TBM. These data suggested that amongst the immunomodulatory drugs, some drugs may be more efficacious than others depending on their ability to selectively delete T-suppressor cells and enhance T-helper and T-cytotoxic cell activity which is necessary to eliminate the tumor cells spared from the toxic action of the drug.

EFFECT OF APROBARBITAL ON PHENOBARBITAL N-GLYCOSYLATION IN MOUSE LIVER MICROSOMES. Vrinda R. Nayak, William H. Soine, and Diana Thomas, Dept. of Medicinal Chemistry, MCV/VCU, Richmond, VA. 23298. N-Glucosylation occurs as a metabolic pathway for phenobarbital in mice. When phenobarbital is incubated with mouse liver microsomal homogenate, phenobarbital N-glucoside is formed and can be quantitated. In the standard assay for the formation of phenobarbital N-glucosides, the incorporation of other barbiturates, such as amobarbital, secobarbital, aprobarbital, hexobarbital, pentobarbital, mephobarbital, butabarbital, butalbital and barbital decreases the formation of phenobarbital N-glucoside. The extent to which these drugs inhibit phenobarbital N-glucosylation was found to depend on the lipophilicity of the barbiturate; the more lipophilic barbiturate causing greater inhibition. To determine if inhibition was associated with concomitant N-glucosylation of aprobarbital present in the assay, aprobarbital N-glucoside was synthesized and characterized. An in vitro assay was developed for the detection and quantitation of aprobarbital N-glucosides, using mouse liver microsomal homogenate. Aprobarbital N-glucosides were formed at a rate comparable to that of phenobarbital N-glucoside formation. Product enantioselectivity was observed with the later eluting diastereomer predominating. (Support : Public Health Service grant, GM 34507).

N-GLUCURONIDATION AS A POSSIBLE METABOLIC PATHWAY FOR AMOBARBITAL IN HUMANS. Vrinda R. Nayak and William H. Soine, Dept. of Medicinal Chemistry, MCV/VCU, Richmond, VA. 23298. N-Glucosylation is a quantitatively significant route for the metabolism of amobarbital in humans and compounds that are substrates for N-glucosylation are usually substrates for N-glucuronidation. It is proposed that amobarbital also undergoes N-glucuronidation in humans. A study is in progress to determine if amobarbital N-glucuronide is excreted after an oral dose of amobarbital. Amobarbital N-glucoside and amobarbital N-glucuronide were synthesized and characterized. A reverse phase HPLC system was developed for the detection of the N-glucuronide metabolites. Using post column ionization, the column effluent could be monitored at a wavelength of 240, thereby enhancing the detection of the metabolites. Amobarbital sodium (100 mg), was administered orally to healthy male subjects and the total urine was collected for a period of 60 hours after dosing. The urine samples were directly analyzed for the presence of metabolites by HPLC. In the subject studied to date, only the previously identified S-diastereomer of amobarbital N-glucoside was detected. There was no evidence for the formation of amobarbital N-glucuronide. This indicates that N-glucuronidation may not be a quantitatively significant pathway for the metabolism of amobarbital in humans. (Support: Public Health Service grant GM 34507).

DECREASED EXPRESSION OF THE ONCOGENE, C-MYC, INDUCED BY VM-26 IN MCF-7 BREAST TUMOR CELLS: IS THE DECLINE IN C-MYC MESSAGE RESPONSIBLE FOR GROWTH INHIBITION? Michael S. Orr and David A. Gewirtz*, Dept. Pharmacology, Medecal College of VA, Richmond, VA. 23298. Various topoisomerase II, inhibitors including m-AMSA and VM-26, produce concentration dependent reductions in expression of c-*myc* (a growth regulatory gene) which parallels growth inhibition in MCF-7 breast tumor cells (Gewirtz et al, Cancer Research 53, 3547, 1993; Bunch et al Biochemical Pharmacology 47, 317, 1994); in contrast, the microtubule inhibitor, vincristine, does not produce a decline in c-*myc* expression. Although cycloheximide (70μM) increases c-*myc* steady state mRNA levels, the protein synthesis inhibitor fails to block the VM-26 induced reduction in c-*myc* expression. This suggests that de-novo protein synthesis is not involved in the influence of VM-26 on c-*myc* expression. Studies assessing the decline in c-*myc* expression in the presence of actinomycin D demonstrates that VM-26 does not alter the stability of the c-*myc* transcript. Preliminary nuclear run off analyses suggest that VM-26 alters the rate of c-*myc* transcription. In MCF-7 cells exposed to VM-26 for three hours followed by a chase with media for up to 72 hours, we observe: a) an initial, early transient decline in c-*myc* gene expression (30% of control levels) followed by b) a return to greater than 60% of control expression within six hours and c) a subsequent decline of c-*myc* gene expression to 40% of control expression at 48 and 72 hours. It is proposed that growth arrest in response to DNA damage produced by topoisomerase II inhibitors is a result of alterations in the activity of regulatory factors which modulate c-*myc* expression in this breast tumor cell line.

CHARACTERIZATION OF PHENOBARBITAL-N-GLUCURONIDE DIASTEREOMERS IN HUMAN URINE. Sheela G. Paibir* and William H. Soine, Dept. Medicinal Chemistry, MCV/VCU, Richmond, VA-23298. In humans, phenobarbital is metabolized by conjugation with glucose to form predominantly (*S*)-phenobarbital-N-glucoside. Drugs known to form glucosides generally form the glucuronides and therefore it is proposed that phenobarbital-N-glucuronide (PbGA) may be a urinary metabolite in humans. (*S*)-PbGA and (*R*)-PbGA and their derivative, (*S*)- and (*R*)-phenobarbital methylglucuronide (PbMGA), respectively, were synthesized and chemically characterized. Phenobarbital (100mg) was given orally to a healthy male and urine was collected for 40 hours following administration of the drug. The urine was concentrated, partially purified by liquid-liquid extraction followed by semi-preparative reversed-phase HPLC. HPLC-UV analysis of the purified urine showed two compounds with similar retention time as that of the standard (*S*)- and (*R*)-PbGA. The UV scans (with and without post-column ionization) of each of these two compounds was identical to that of the standard PbGA under the same conditions. On derivatization, the products from biological origin had similar retention times and UV characteristics (with and without post-column ionization) as that of the standard (*S*)- and (*R*)-PbMGA. This evidence indicates that (*S*)- and (*R*)-PbGA are metabolites of phenobarbital in humans. These metabolites together account for approximately 7% of the oral dose. (Supported by NIH Grant GM 34507).

CD44-HYALURONIC ACID INTERACTIONS IN LYMPHOCYTE CELL ACTIVATION. Asimah Rafi*, and P. Nagarkatti. Department of Biology, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061.Adhesion molecules play an important role in cell-cell and cell-extracellular matrix interactions. Such interactions are crucial to all developmental processes. Recently, adhesion receptors and interaction of lymphocytes with extracellular matrix (ECM) has been shown to play a central role in regulating the migration, differentiation and functions of the cells of the immune system. Our lab has demonstrated that activated cytotoxic T lymphocytes (CTL) can mediate efficient lysis of target cells when activated through adhesion molecule, CD44. CD44 is expressed on a wide variety of cell types, including T cells, thymocytes, B cells, and granulocytes and has been shown to bind to ECM components such as hyaluronate. In this study we looked at the role of hyaluronate in the activation of lymphocytes. Spleen cells incubated with anti-CD44 monoclonal antibodies (mAbs) or hyaluronate proliferated strongly in vitro. Interestingly, purified B lymphocytes but not T cells responded by proliferation. The T cells failed to respond to hyaluronate even in the presence of accessory cells. Bone marrow cells were also found to express CD44 and demonstrated a proliferative response to stimulation with hyaluronate. Together our data suggested that hyaluronate plays an important role in the differentiation of lymphocytes and their functions in vivo.

THE EFFECTS OF PRENATAL STRESS ON THE SIZE OF THE CORPUS CALLOSUM. R. Rowe, B. Donnelly*, K. Golden*, H. Jones, B. Bailey*, C. Kinsley, Dept. of Psych., Univ. of Richmond, Richmond, Va. 23173.The effects of prenatal stress on the size of the corpus callosum in rats was investigated using a prenatal heat, light, and restraint stress paradigm that influences the fetal hormonal milieu. Females were stressed three times daily from day 13 of pregnancy through parturition. Control females were left unstressed through parturition. At approximately 215 days of age, males and females from the two groups were sacrificed. Area (squared mm) of the corpus callosum was determined from sagittal sections of each brain. A main effect existed for sex, $F(1,25)=15.187$, $p=.001$, with males having a larger corpus callosum than females. The predicted sex by stress interaction was not apparent, although the means were in the hypothesized directions. The results support previous findings that the corpus callosum is sexually dimorphic. The results also suggest that prenatal stress may not have as great an effect on the development of the corpus callosum as it does on other structures in the brain. Measurements of perimeter and length are currently being investigated.

SURFACE LAYERS AS A POTENTIAL MECHANISM FOR GENETIC EXCHANGE IN STREPTOCOCCI. Andrea C. Scharfe and Lynn O. Lewis, Dept. of Biological Sciences, Mary Washington Col., Fredericksburg, VA 22401-5358. Antibiotic resistance in streptococci has been documented worldwide, however the mechanism leading to the spread of antibiotic resistance is not known. Gram negative bacteria often conjugate to transfer antibiotic resistance plasmids, but conjugation in streptococci has not been demonstrated. One hypothesis for mating in Gram positive organisms involves the presence of a protein layer on the outside of the cell, known as an S-layer. The literature does not show streptococci to have S-layers, however these organisms may not have been examined. Therefore, two strains of *Streptococcus pneumoniae*, one which is penicillin resistant and one which is not, are being examined for the presence of S-layers. Preliminary data indicate that protein can be extracted from the surface of the nonresistant *S. pneumoniae*. Therefore, further studies will be done to determine whether these proteins are S-layers and whether they may participate in mating between streptococci.

QUANTIFICATION OF ORGANIZATION OF VENTRICULAR FIBRILLATION. Samir Shah, Peng-Wie Hsia*, Ralph Damiano Jr.*, Dept. of Biomed. Eng. and Surgery, Medical College of Virginia, Richmond VA 23298. Ventricular Fibrillation (VF) is characterized by irregular and random patterns of epicardial electrical activation and contraction of the myocardial muscles. VF is terminated by delivering a DC shock to the heart (defibrillation). The outcome of a defibrillation attempt, however, remains largely probabilistic. Clinically, shocks of energy levels 2 to 3 times the calculated minimum are routinely used to compensate this uncertainty. However, the high energy shock may damage the heart. Hence, lowering the defibrillation shock energy level has been a long-standing goal. Previous studies suggested that there exist "windows" during VF when the fibrillatory process is more vulnerable to defibrillation. This could explain the probabilistic nature of defibrillation. In this paper we further hypothesize that the underlying level of organization of epicardial activation during VF may affect the defibrillation success and help identify a vulnerable window to defibrillation. In a canine defibrillation study, unipolar electrograms were recorded from 112 closely spaced sites on the epicardial surface. Using vector-loop methods, the direction of epicardial activation was determined at 90 individual sites for 5 successive beats during VF. A multiple linear regression model was used to predict the direction of epicardial activation at a site from those at adjacent sites during the same beat and at corresponding sites during the previous beat. The normalized coefficient of correlation between the predicted and observed values of epicardial activation direction was used to quantify the level of organization. The effect of this quantified level immediately prior to a defibrillation trial on the outcome of the trial was studied.

CLONING AND CHARACTERIZATION OF A MAIZE β-GLUCOSIDASE ALLELE. Mohammad Shahid and Asim Esen, Dept. of Biol., VA Polytechnic Inst. & State Univ., Blacksburg, VA 24061. Maize β-glucosidase is the most polymorphic enzyme with 31 allozymes. These allozymes detected by conventional electrophoretic methods, represent only 25% of the total variation at amino acid level. Thus >100 mutants at the protein and several hundred at the nucleotide level are expected. It is not known whether these mutations are scattered throughout coding sequence or clustered at particular regions (hot spots). We made oligonucleotide primers based on N-terminal sequence of the maize enzyme and conserved regions of β-glucosidase from other organisms to amplify and clone the 5' region of the Glu1 locus from maize cDNA. The clone was sequenced and confirmed to be β-glucosidase. Then the clone was used to isolate a near full-length β-glucosidase cDNA from the cDNA library of maize inbred K55. After isolation, the β-glucosidase cDNA was sequenced and found to be 1931 bp long. The cDNA is coded for a 566 amino acids long protein and 512 amino acid long mature protein. When the sequence was compared with the sequence of another maize β-glucosidase cDNA (zm-p6.1), 15 nucleotide differences was observed within open reading frame. Three of these nucleotides substitutions resulted in amino acids substitutions. We also have shown that the genomic DNA encoding maize β-glucosidase lacked intervening sequences (intron).

EVALUATION OF ACUTE AND CHRONIC ANABOLIC STEROID TREATMENT ON THE SEROTONIN TRANSPORT SYSTEM.Suzanne R. Thornton and David R. Compton, Dept. of Pharm./Tox., Med. Col. of Va., Richmond, Va. 23298.Over the last 10 years, there has been a dramatic increase in the abuse of synthetic androgenic/ anabolic steroids which prompted the passage of the Anabolic Steroids Control Act of 1990. Dosages of 10 to 100 times therapeutic levels have been reported. Symptoms such as depression, aggression, psychosis and mania have also been reported anecdotally. Depression can be treated with antidepressive drugs such as fluoxetine which prevent uptake of serotonin from the synaptic cleft. The depression reported during steroid abuse and after discontinuation has been treated with fluoxetine (Malone and Dimeff, 1992). The present study was conducted to determine the effects of acute and chronic steroids on the serotonin transport system. The study was conducted using male ICR mice (weighing 25-30 g) injected I.P. with either sesame oil (vehicle) or sesame oil with 5% benzyl alcohol or 500 mg/kg of nandrolone deconoate, nandrolone propionate, testosterone deconoate and testosterone propionate. The acute steroid treatment groups were sacrificed one hour after injection while the chronic steroid treatment groups were treated for four weeks and sacrificed one hour after their final injection. Animals were decapitated and homogenates of cortical tissues prepared for binding using [^{3}H]-paroxetine. There was no statistically significant effect on the K_d or B_{max} of the serotonin transport system for any of the steroid treatments. The anecdotally reported depression following chronic anabolic steroid abuse seems to be similar to other clinical depression which responds to fluoxetine. These data suggest that anabolic steroids do not have either direct or indirect effects on the serotonin transporter, as might have been suggested by the results of fluoxetine treatment of humans suffering "withdrawal" from anabolic steroid abuse. The depression, if produced, may still be due to other alterations of the serotonin neurotransmission system, such as synthesis, release or postsynaptic receptors.

THE EFFECTS OF PRENATAL STRESS ON THE QUANTITY OF ULTRASONIC VOCALIZATIONS PRODUCED BY MALE AND FEMALE RATS DURING SEXUAL ENCOUNTERS. N.C. Turner, J.A. Eskandarian, C.H. Kinsley, Dept. of Psych., Univ. of Richmond, Richmond, Va. 23173. Ultrasonic vocalizations (UVs) are an important means of communication among rodent species, especially during sexual activity. Many studies indicate that prenatally stressed (PNS) animals show deficits in sexual behavior. The purpose of the present study was to examine the effects that PNS has on UV production. The stress procedure, which began on day 15 of gestation and continued through day 22, consisted of exposing the female to a regimen of heat and restraint for 30 minutes 3 times a day. The offspring were then tested when they reached adulthood (~110 days). We observed the frequency of occurrence of UVs produced by control and PNS, male and female rats during exposure to an anesthetized sexually receptive opposite-sex stimulus animal. We found that the control females produced significantly more UVs than the control males. The control females also produced a significantly greater amount of UVs than the PNS females. The amount, however, of UVs emitted by the control males and PNS males was not significantly different. Likewise, the PNS males and the PNS females showed no significant difference in UV production. Analysis indicates that when a female is PNS, her quantity of UVs decreases to a number which resembles that of the control male. Therefore, it can be inferred that the PNS female has become masculinized, and/or defeminized.

FIBROSARCOMA-INDUCED ALTERATIONS IN HELPER T-CELL ACTIVATION INVOLVE DECREASE RESPONSIVENESS TO CO-STIMULATORY CYTOKINES AND INCREASED SENSITIVITY TO SUPPRESSOR CYTOKINES. Thomas M. Walker and Klaus D. Elgert, Dept. of Biol., Va. Polytechnic Inst. & State Univ., Blacksburg, Va 24061-0406. Tumor growth induces several functional changes among immune cell populations. $CD4^+$ helper T cells represent a significant effector component of the immune system, and their activities are dictated by their responsiveness to cytokines. The current investigation evaluated tumor-induced alterations in helper T cell responsiveness to several cytokines involved in T-cell activation and downregulation. We also evaluated tumor-induced changes in helper T cell responses to the anti-cancer drug taxol. T-cell responsiveness to specific signals was assessed by measuring T-cell proliferation. Specific cytokines associated with T-cell activation such as interleukin-2 (IL-2) and interferon-gamma (IFN-γ) could partly restore tumor-bearing host (TBH) T-cell proliferation to levels comparable to normal host (NH) T cells, but this effect was blocked by the suppressor cytokines interleukin-10 (IL-10) and transforming growth factor-beta, (TGF-β_1). TBH helper T cells were unresponsive to the co-stimulatory cytokines interleukin-1 (IL-1) and interleukin-6 (IL-6) and produced lower concentrations of upregulatory cytokines during activation. TBH helper T cell showed a higher sensitivity than NH helper T cells to IL-10 and TGF-β_1. We have previously shown that these two suppressor molecules are produced by suppressor immune cells and cancer cells. TBH helper T cells also demonstrated a higher sensitivity to the anti-mitotic compound taxol. TBH T-cell sensitivity to taxol was significantly increased by TGF-β_1. These data collectively suggest that tumor growth changes helper T cell responsiveness to specific regulatory signals associated with T cell activation and downregulation. Furthermore, our data suggest a novel mechanism of T-cell suppression by taxol during tumor growth and may partly explain the limited success of taxol as an effective immunotherapy for cancer patients.

MORPHOMETRIC POST NATAL DEVELOPMENT OF THE MOUSE SEMINAL VESICLE. Matthew B. Zook and Roman J. Miller. Eastern Mennonite Col., Harrisonburg, Va. 22801. The histology of the mouse seminal vesicle was studied to determine significant developmental events. Using light microscopy, morphometric analysis was done at day (d) 20, 30, 40, 50, 60, 90, and 120 postnatal. Parameter changes (rate units = +/- μg or μl/organ/day) were determined for stromal (ST), glandular (GT), and total lumen (TL) area comprised of empty area and secretions. All three areas significantly increased from d 20 to d 40 (ST = +330; GT = +700; TL = +1,180). From d 50 to d 90 ST decreased in value (-125) while GT showed a decreased rate of growth (+286). TL remained relatively constant during this time, but increased after d 90 (+630). TL increase was due primarily to secretion material, which increased at an approximate rate of +850 during the d 20 to d 40 and d 90 to d 120 periods. No change was found in the epithelial cell length, width, or nucleus/cytosol ratio over the time period. Growth occured rapidly from d 20 to d 40 in all tissues. GT and TL growth rate decreased from d 40 to d 90 while ST area decreased over this period. TL increased more rapidly after d 90. Based on these biological indicators, seminal vesicle functionality is reached by d 40 and organ maturation between d 90 and d 120.

Microbiology and Molecular Biology *(No Abstracts Submitted)*

Natural History and Biodiversity

USE OF PONDS TO PROTECT NATIVE FRESHWATER MUSSELS. Jonathan W. Burress and Dick Neves, Dept. of Fisheries and Wildlife, Virginia Tech, Blacksburg, Va. 24061-0321. The survival of 12 species of freshwater mussels was monitored in ponds at 3 study sites in Critz, Blacksburg, and Marion, Virginia . Mussels were held within 1m x 1m x 0.5m plastic screen cages fastened to PVC float collars. Holding methods consist of placing mussels unrestricted on cage bottoms and within 100mm mesh plastic sleeves hung horizontally from the cage tops. Survival in the farm pond at Critz was 74% overall, with significant differences in survival after 1 year of captivity. *Elliptio* spp. exhibited high survival (x=94%), whereas survival of *Pleurobema cordatum* and *Lampsilis ovata* was lower (74% and 36%, respectively). Survival of mussels in the pond at Blacksburg was higher (>93%) after 5 months, whereas survival at Marion was high (x=85%)in sleeves but low in mussels placed on the cage bottom.

EVALUATING EFFECTS OF PRESCRIBED BURNING ON AN ENDANGERED PLANT: PETERS MOUNTAIN MALLOW. Caren A. Caljouw, Dept. Conservation and Recreation, Div. Natural Heritage, 1500 E.Main St., Suite 312, Richmond, Va. 23219, M.V. Lipscomb, Dept. Biology, Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061, S.A. Adams, D.S. Lancaster Community Col., Clifton Forge, Va. 24422, & M.S. Hobbs, Va. Field Office, The Nature Conservancy, Charlottesville, Va 22903. In 1991, just three individuals of the federally endangered plant, Peters Mountain mallow (Iliamna corei) remained in the wild. In 1992 and 1993, prescribed fire was used in an attempt to stimulate seedling recruitment in the population. Eleven plants appeared in a burn plot in 1992, of which three survived to 1993. A burn in 1993 yielded an astounding 495 seedlings. Such results portray Peters Mountain mallow as a fire dependent species, and emphasize the importance of prescribed fire as an ecological management and endangered species recovery tool. Population monitoring is on-going and additional burns are planned. In an effort to understand the factors that may have contributed to the decline of Peters Mountain mallow and the role that fire has played in maintaining this endangered species, disturbance history studies were initiated in 1992. Preliminary investigations reveal that the mean fire return interval for this site was 6.1 years.

THE SUCKING LICE (INSECTA: ANOPLURA) OF VIRGINIA SCIURIDS. Ralph P. Eckerlin and Harry F. Painter, Natural Sciences Div., Northern VA Cmnty. Col., Annandale, VA 22003. All seven species of the mammalian family Sciuridae were examined for lice. Woodchucks (n=15), red squirrels (n=7), northern flying squirrels (n=2), and southern flying squirrels (n=6), were without lice. One chipmunk of 26 examined was infested with Hoplopleura erratica, a new state record. Fox squirrels (n=9) had Hoplopleura sciuricola, Neohaematopinus sciuri, Neohaematopinus sciurinus, and Enderleinellus longiceps. Only N. sciurinus is new to the Virginia fauna. Gray squirrels (n=128) were hosts to N. sciuri (22% prevalence) and H. sciuricola (6% prevalence). The prevalence and intensity of louse infestations from these road kill gray squirrels from northern VA were much lower than those of another study using shot or trapped gray squirrels from southwest VA.

AN EXEMPLARY FIRE-MAINTAINED ECOSYSTEM IN THE VIRGINIA PIEDMONT. Gary P. Fleming, Va. Dept. of Conservation and Recreation, Div. of Natural Heritage, Main Street Station, 1500 E. Main St., Suite 312, Richmond, VA 23219. Fort Pickett is a 45,000-acre U.S. Army installation occupying parts of Nottoway, Brunswick, and Dinwiddie Counties in the southern Virginia piedmont . Within the base, a 10,000-acre controlled access area, which contains firing ranges and target sites for artillery and small arms training, has been subjected to very frequent wildfires and some prescribed burns during the past fifty years. In the course of a base-wide inventory for rare species and significant communities, Division of Natural Heritage biologists discovered that the regularly burned landscape supports extensive pine and hardwood savannas, open seepage wetlands, and occurrences of several rare species. These included the largest known population of the federally endangered shrub Michaux's Sumac (*Rhus michauxii*) and viable populations of Bachman's Sparrow (*Aimophila aestivalis*), a candidate for federal listing. Fire-maintained woodlands and savannas were present historically in southeastern Virginia, but have almost entirely disappeared because of fire suppression and other recent disturbances. As a result of the Fort Pickett inventory, management and research are now underway to ensure the long-term conservation of these rare community types and species in the Commonwealth.

POSSIBLE DIVERSITY IMPLICATIONS: 1992-3 TURKEY RUN PARK HERPETOLOGICAL SURVEY Dean A. Lindholm, 14226 Glenkirk Rd., Nokesville, VA 22123 (under contract to National Park Service). A one year, approx. 175 hr. survey by 4 people discovered 4 salamander, 2 toad, 6 frog, 1 turtle, 2 lizard, and 6 snake species within the wooded, 300 acre Turkey Run park. These specimens represent only what was found during this inventory; they should not be taken as a complete list of park herpetofauna. Varying population evidence is discussed. Examination as well as photographic evidence of these specimens illustrate that they are all common Piedmont sp., and make up only part of potential populations. Yet this park is surrounded by the Potomac river and Washington D.C. suburbs. Does this study have diversity implications? This question is addressed, and related to recent declines in herpetofauna.

DISTRIBUTION AND ECOLOGY OF STREAM-DWELLING CRAYFISHES IN THE CLINCH RIVER DRAINAGE, VA. Patrick S. Lookabaugh*, Paul L. Angermeier*, and Richard J. Neves, Dept. of Fisheries and Wildlife Sciences, Virginia Tech, Blacksburg, VA 24061-0321. Species composition and distribution of stream-dwelling crayfishes were determined at 34 sites throughout the Clinch River drainage of Virginia. Six species were collected: *Cambarus (Cambarus) angularis, C. (C.) bartonii, C. (Hiatacambarus) longirostris, C. (Puncticambarus) buntingi, Orconectes (Procericambarus) forceps, and O. (P.) spinosus. Cambarus (C.) angularis, C. (H.) longirostris, and O. (P.) spinosus* were distributed widely in the drainage, whereas other species, especially *O. (P.) forceps*, were localized. *Cambarus (P.) buntingi*, which occurred in the Guest River drainage, was recorded for the first time in Virginia. A "saddled" form of *C. (H.) longirostris* was collected in the upper reaches of Copper Creek. Preliminary analyses suggest higher relative abundances of orconectids in degraded areas.

ALLOZYMIC VARIATION IN MAINLAND AND INSULAR POPULATIONS OF ORYZOMYS PALUSTRIS AND PEROMYSCUS LEUCOPUS . Janet L. Loxterman[1], Nancy D. Moncrief[2], Raymond D. Dueser[3], & John F. Pagels[1]. [1]Dept. Biology, Virginia Commonwealth Univ., Richmond, VA 23220, [2]Virginia Mus. Nat. Hist., Martinsville, VA 24112, and [3]Dept. Fish. & Wildl., Utah State Univ., Logan, UT 84322. We examined allozymic variation in mainland and insular populations of the marsh rice rat (Oryzomys palustris) and the white-footed mouse (Peromyscus leucopus). The sampling localities include four sites on the Eastern Shore of Virginia and five sites on adjacent barrier islands. A total of 118 rice rats from nine sites and 96 white-footed mice from seven sites were assayed at more than 32 presumptive gene loci. To date, rice rats are variable at 5 of 32 loci: PGM3, 6PGD, NP, G3PD, and ADA. White-footed mice are variable at 7 of 32 loci: G6PD, PEPA, IDH2, MPI, NP, PGM1, and ADA. Preliminary results indicate that O. palustris exhibits less genetic differentiation among populations than does P. leucopus. These differences in levels of intraspecific variability may be related to colonization ability. We hypothesize that rice rats are relatively good dispersers among islands and adjacent mainland sites, whereas white-footed mice are relatively poor dispersers across water barriers.

BIOLOGICAL CONTROL OF PURPLE LOOSESTRIFE. Tom J. McAvoy, L. T. Kok* and W. T. Mays*, Dept. of Entomology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061. Purple Loosestrife (*Lythrum salicaria* L.) is a weed of freshwater wetlands that forms extensive monospecific stands eliminating native plants. In 1989 three species of Coleoptera: *Hylobius transversovittatus* (Curculionidae), *Galerucella calmariensis* and *G. pusilla* (Chrysomelidae) were received at the Quarantine Lab of the Department of Entomology at V. P. I. & S. U. for host specificity studies. Fifteen species of plants from nine families were tested to determine their suitability for feeding, oviposition, larval development and oogenesis. *Lythrum virgatum* and *L. alatum* were found to be hosts of all three species. In addition, *Decodon verticillatus* was found to be a host of *H. transversovittatus*. However, preference was for *L. salicaria*. As the three beetles were found to be adequately host specific, they were officially approved for field release in the United States in 1992. Releases of all three species were made in Coeburn, Va. in 1992 and *H. transversovittatus* and *G. pusilla* were released near Sweet Chalybeate, Va. in 1993. The two *Galerucella* species released in 1992 were recovered in May 1993 in Coeburn, Va.

A BUTTERFLY SURVEY AT THE VIRGINIA TECH HORTICULTURE GARDENS. Tom J. McAvoy, W. T. Mays*, Dept. of Entomology, and B. Lyons*, Dept. of Horticulture, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061. A weekly butterfly survey was conducted at the Virginia Tech Horticulture Gardens from April 27 to October 19, 1993. Twenty six butterfly species (Superfamily: Papilionoidae) were recorded. The five most abundant species and the total number found were *Pieris rapae* (108), *Danaus plexippus* (90), *Colias eurytheme/philodice* (34), and *Speyeria cybele* (14). One individual of a rare species was observed, *Speyeria atlantis*, this species has a state ranking of S2. Nectar was gathered from a total of 37 species of plants from 24 plant families. The five most attractive plant species and the total number of butterflies that gathered nectar from them were: *Buddleia davidii* (124), *Rudbeckia purpurea* (41), *Zinia elegans* (28), *Gomphrena globosa* (17) and *Coreiopsis* sp. (13). The total number of butterflies and the color of the flower that they gathered nectar from were: 243 from purple/blue, 36 from red/pink, 26 from white, 18 from yellow and 4 from orange.

AMPHIBIAN BIODIVERSITY AND COMMUNITY STRUCTURE IN FIVE FORESTED HABITATS ON SHENANDOAH MOUNTAIN, VIRGINIA. Joseph C. Mitchell, University of Richmond, VA 23173, Kurt A. Buhlmann, Savannah River Ecology Lab, Aiken, SC 29802, Christopher A. Pague, Colorado Natural Heritage Program, Boulder, CO 80309. We conducted a 2-yr study of amphibians communities in five montane habitats that reflect different management practices in the George Washington National Forest. A total of 1334 individuals representing 11 species of salamanders and 5 species of frogs were sampled with drift fence/pitfall trap arrays April 1987-October 1988. Numerically dominant species were Ambystoma jeffersonianum, Plethodon cinereus, and Rana sylvatica. Amphibian species richness and population sizes were highest in less disturbed habitats and those not affected by timber harvest practices, such as in older forests with downed woody debris. Species richness was also highest in habitats adjacent to springs and wildlife ponds. Aquatic resources and their surrounding forested habitats should be viewed as keystone resources for amphibians in temperate zone montane forests. (Supported by a Challange Cost Share from the George Washington National Forest.)

DISCOVERY OF A VIRGINIA "SERPENTINE BARREN". Thomas J. Rawinski, Dept. of Conservation and Recreation, Div. of Natural Heritage, Main Street Station, 1500 E. Main St., Suite 312, Richmond, VA 23219. Serpentine barrens are rare and fascinating natural environments that support distinctive vegetation adapted to harsh edaphic conditions. The famous serpentine barrens of southeastern Pennsylvania and adjacent Maryland, and the Buck Creek serpentine barren in Clay County, North Carolina had no known Virginia counterpart until 1992 when such a barren was discovered along Jacks Creek in Franklin County. This barren contains natural grassland fringed by a woodland of Pinus virginiana, Juniperus virginiana, Quercus stellata, and Quercus marilandica. The grassland, which is dominated by Schizachyrium scoparium, Senecio plattensis, and Parthenium auriculatum, contains a unique assemblage of plants consisting of Sporobolus heterolepis (first Virginia record), the shale barren plant Trifolium virginicum (new southern range limit), the limestone glade plant Arenaria patula (first Piedmont record), and Talinum teretifolium. The shallow friable soil, derived from ultramafic rock of the Alligator Back Formation, has a pH of 7.0 and a calcium to magnesium ratio of 0.22. The site is privately owned and access is severely restricted at this time. Efforts to conserve this highly significant site are underway.

MAMMAL BIODIVERSITY AND COMMUNITY STRUCTURE IN FIVE FORESTED HABITATS ON SHENANDOAH MOUNTAIN, VIRGINIA. John F. Pagels & Sherry C. Rinehart, Dept. of Biol., Va Commonwealth Univ., Richmond, Va. 23284, Joseph C. Mitchell, Dept. of Biol., Univ. of Richmond, Richmond, Va. 23173, Kurt A. Buhlmann, SREL, Aiken, SC. 29802 & Christopher A. Pague, Natural Heritage Program, Boulder, Co. 80309. A total of 752 small mammals that represent 15 species was pitfall trapped in five stands that reflect different management practices. Species diversity (H′) was highest in a severely thinned site (1.977) and lowest in a mature forest site (1.443). Five species of shrews (Blarina and 4 Sorex) comprised the majority of the total specimens (75.5%) and were present at all five sites. Cover objects and floral characteristics were critical habitat components. Results demonstrate that intermittent openings in the forest are beneficial to certain mammals on Shenandoah Mountain. Discussion will include thoughts on the influence of various management practices on small mammals.

THE ODONATE FAUNA OF FORT A.P. HILL. Steven M. Roble and Christopher S. Hobson*, Dept. of Conservation and Recreation, Div. of Natural Heritage, 1500 E. Main St., Suite 312, Richmond, VA 23219. Fort A. P. Hill Military Reservation is located in Caroline County, an area rich in acidic wetland habitats. Extensive beaver activity has resulted in the creation of numerous pond habitats on the base. The odonate fauna was sampled during 1993, particularly during the summer and fall months. A total of 61 species (23 damselflies and 38 dragonflies) was documented. This represents 33% of the total Virginia fauna and an even greater percentage of the lentic species. Thirty (49%) of the species are considered rare (14) or uncommon (16) in the state by the Division of Natural Heritage. Several of these species are closely associated with acidic pond habitats. Significant findings include the first records of Nannothemis bella in Virginia in more than a century, one record of Lestes congener, a species previously unknown from the state, and the southernmost documented localities for Celithemis martha. Three exemplary acidic pond habitats supported the greatest species diversity. Two ponds support at least 22 different species; a minimum of 20 species inhabit the third pond. Additional surveys in the spring and early summer of 1994 are likely to add to the known odonate fauna of Fort A.P. Hill.

AN INSTRUCTIONAL DESIGN MODEL FOR THE USE OF UNIVERSITY RESEARCH COLLECTIONS IN UNDERGRADUATE EDUCATION. S. Llyn Sharp. Virginia Tech Museum of Natural History, 428 North Main Street, Blacksburg, Virginia, USA 24061-0542. The systematics and collections community has realized that it is imperative for the public and administrators to *personaly value* the natural history collections in our care. University collections are particularly vulnerable to administrative and faculty changes of direction; their inherent value notwithstanding, collections which are not seen as directly related to the primary mission of undergraduate education may appear to be unaffordable luxuries in times of limited funding. Direct experience with the "real thing" makes science exciting and leads students to scientific inquiries of their own. Undergraduate education has always used teaching collections for hands-on experience: this can be enhanced by the resources of research collections. This model integrates research collections into the curriculum while minimizing risks to their preservation for future uses by using both physical and procedural controls. Student, faculty, and museum staff evaluations of its effects will be presented, as well as future plans based upon that feedback. The implementation of this model invites additional audiences to appreciate the wealth of information in natural history objects and understand their potential for future studies of biodiversity. These collections can be shown to be not unaffordable luxuries, but additional investments in educational excellence.

TEACHING LOCAL NATURAL HISTORY THROUGH SCHOOLYARD INQUIRY. Frank Taylor, Virginia Tech Museum of Natural History, Virginia Tech, Blacksburg, VA 24061-0542. Virginia natural history and ecology can be taught through direct hands-on experiences using the schoolyard as a laboratory. MINTS -- Museum Inquiry-based Natural history guides for TeacherS is a five year project funded by the Howard Hughes Medical Institute's Precollege Science Initiative for Science Museums that provides teachers with both scientific content knowledge and a model for inquiry instruction in the outdoors. The scientific content in the guide is organized by habitat - parking lot, lawn, fencerow and overgrown areas, walls and eaves, and trees. Organisms and how they interact with the biotic and abiotic features of the environment are addressed in each section. The inquiry model is based on national science reform efforts -- using open ended questions to engage students in making observations, using simple science tools to collect data, organizing and communicating data, and making inferences and conclusions. MINTS will be of interest to all science educators whose goals are to involve students in direct experiences discovering natural history. The guide is currently being field tested and is available to educators by attending a workshop through the Virginia Tech Museum of Natural History.

THE PUBLIC'S ATTITUDES TOWARD SNAKES: PRELIMINARY SURVEY RESULTS FROM PARK-GOERS. Robert A. S. Wright, Central Va. Biological Research Consortium, 7551 Devil's Den Lane, Mechanicsville, VA 23111. During an 11-day interval in August 1985, a voluntary survey questionaire was circulated in a public park as part of an educational display featuring snakes and their conservation. Respondents were asked to fill out the form which collected qualitative/demographic data such as age, gender, occupation, educational level, and residence. Questions were posed to determine the respondents' knowledge of local venomous snakes, their identification/differentiation from non-venomous species, and whether they had a fear or phobia of snakes. Respondents were asked to provide objective statements as to why or why not snakes were important to the environment; they were also asked to provide a brief statement that summarized their feelings about snakes. The details of this study are presented and discussed.

Psychology

ESTABLISHING CONDITIONS: INCREASING TRAFFIC SAFETY BEHAVIORS WITH PERSON-BASED MESSAGES. Brenda R. Alderman, Jason N. Fortney, Trish Dorsey, Brenda R. Wetzel, & Mary Spiller, Dept. of Psyc., VA Tech, 5100 Derring Hall, Blacksburg, VA 24061-0436. In the first six months of 1993, over 2,300 rail-highway crossing incidents occurred nationwide—including 284 fatalities and 863 injuries—because automobile drivers violated traffic safety laws at crossings. A review of the literature identified antecedent and consequent conditions which may direct and motivate unsafe crossing behaviors, and examined past research and interventions. This study identified existing driver behavior at selected local crossings and applied a novel community intervention using a behavioral paradigm based upon person, environment and behavior factors.

A BEHAVIORAL ASSESSMENT OF THE RISK COMPENSATION HYPOTHESIS. Thomas E. Boyce, Jason N. Fortney, C. Matt Rashleigh, & Mark Newell, Dept. of Psyc., VA Tech, 5100 Derring Hall, Blacksburg, VA 24061-0436. The Risk Compensation hypothesis (Peltzman, 1975) was tested by exposing human subjects to a computer analogue of an industrial risk-taking situation. This ABA design included two manipulations of perceived risk. Group 1 experienced a lowered level of perceived risk, while Group 2 experienced an increased level of perceived risk. Subjects also completed Zuckerman's (1979) Sensation Seeking Scale and Geller's (1991) Risk Probability Survey. A manipulation check was performed by assessing subject's self-reports of the perceived risk manipulations. Results are discussed from the behavior analytic and social psychological perspectives.

RED CROSS BLOOD DONORS VS. A SAMPLE OF STUDENTS: AN ASSESSMENT OF DIFFERENCES BETWEEN GROUPS ON "ACTIVELY CARING" PERSON FACTORS. Curtis M. Buemeyer, David Rasmussen, D. Steve Roberts, Craig Martin & Amy Gershenoff, Dept. of Psyc., VA Tech, Blacksburg, VA 24061. Actively Caring", as defined by Geller (1993), is behaving "beyond the call of duty" to help another person. Purportedly, three individual difference factors, self-esteem, empowerment and feelings of belonging to a group, give a person the propensity to "actively care" (AC). Though the AC paradigm possesses strong face validity, more evidence is needed to link AC person factors with actual behaviors. The "Blood Drive Questionnaire," an inventory comprised of six AC sub-scales, was administered to both a control group (n=270) and a group of Red Cross Blood Donors (n=170). A one tailed t-test was used to test for significant differences between groups. As hypothesized, blood donors did indeed evidence higher scores on all six scales: self-efficacy, optimism, personal control (which comprise the "empowerment" factor) beloningness, and self-esteem.

IMPROVING VIGILANCE PERFORMANCE THROUGH THE USE OF HIGHLY ACQUAINTED INDIVIDUALS. Peter J. Ceplenski, Mark Scerbo, Debra Major. Old Dominion Univ., Norfolk, Va. 23529. The effects of using two-person monitoring teams composed of highly acquainted individuals on vigilance performance and workload were examined. Previous findings suggest that using two-person monitoring teams improves detection probabilities over that of individual monitors.(Schafer, 1943). It was hypothesized that friendship pairs would perform better than two-person teams of strangers or individuals, as well as rate the task lowest in workload. Sixty undergraduate subjects participated and were assigned to one of the three experimental conditions. The vigilance task was a visual successive judgement task using squares as stimuli. An ANOVA revealed no significant differences between conditions on both the performance measures and workload scale. Task complexity and verbal communication are discussed as explanations for the findings.

SCHEMATIC FACES AND CHOICE REACTION TIME. Samuel L. Chapman, Peter J. Mikulka*, & Glynn D. Coates*, Dept. of Psychology, Old Dominion University, Norfolk, VA 23508. The present study investigated categorization of schematic faces as a function of the amount of information presented. It was hypothesized that, as faces became more realistic, parallel processing would emerge. It was also hypothesized that: 1) choice reaction time (CRT) would increase with display set size, 2) CRT would remain constant with an increase in the number of features if the schematic faces were parallel processed, 3) accuracy would decrease with a subsequent increase in display set size and feature number, 4) learning would occur as accuracy increased with time. Subjects were 52 undergraduates, 45 females and 7 males. Schematic faces were presented on the screen of an IBM compatible 386 personal computer. The target face and display set were shown simultaneously. Subjects were required to decide if the target face was an exact match of any face in the display set. An analysis of variance (ANOVA) for CRT and accuracy was performed using 3 levels of display set size, 3 levels of number of features varied, 4 levels of blocks, and 2 levels of response condition (either the target was present in the display set or not). Every subject received all of the conditions. For CRT, eleven significant effects were found. For CRT, four effects were discussed because the omega-squared was greater than .02. A significant main effect was found for display set size; CRT increased as predicted as stimulus number increased. A significant main effect was found for features; CRT increased as the number of features increased indicating novel faces being processed serially. A significant main effect for trial blocks showed that subjects improved their performance over time which indicated learning. A significant interaction was found for display set size x response condition. For accuracy, seven effects were found to be statistically significant, but none reached an omega-squared of .02. It would be of interest to expand the display set and the number of features varied in order to assess subjects' capacity to perform the task efficiently and an assessment of strategy shifts. Also, in order to evaluate parallel processing, subjects could view the target face for a period of time before the task.

MEXICAN FREE-TAILED BATS AT MT. LAKE BIOLOGICAL STATION! Jack A. Cranford, and Deborah S. Fortune., Mt. Lake Biological Station, Biology Dept, Univ. of Virginia, Pembroke, VA. In the fall of 1994 during the course of routine mammal trapping, mist netting of bats and direct observation produced the normal expected results. Big and little brown bats, red bats, hoary bats and eastern pipistrellus were recorded. On one occasion a large bat was observed in the library area in the research building at the station. This animal was captured by hand and two days later another was captured in a bug net. These bats either entered through the open library windows or came down from the attic. Both were identified by the free-tail condition, ear shape and body coloration as Mexican free-tailed bats (*Tadarida brasiliensis*). After identification and measurement both were released and flew in the area of the laboratory driveway foraging and entering the eve of the building.

HABITUATION TO SPECIFIC SENSORY STIMULI IN SENSITIZED EPILEPTIC MONGOLIAN GERBILS (Meriones unquiculatus). Stephen R. Davenport, C. Grandinetti, & J.W. Collins, Dept. of Psychology, Washington & Lee University, Lexington, VA 24450. Five groups of genetically epileptic Mongolian gerbils were individually exposed to five distinct stimuli during sensitization and subsequent habituation phases. Inter-test intervals were seven days for sensitization and two days for habituation. Each group was exposed to a novel stimulus on the seventh test in each phase to determine stimulus generalization for seizure expression and severity. All animals were tested for emotionality in a two-compartment box (1mx1m floor space) after sensitization and habituation phases. Results suggest a stimulus generalization present across most of the stimulus conditions in both sensitized and habituated animals. High emotionality was associated with the sensitization phase with low emotionality scores noted after habituation, regardless of the stimulus condition. The presence of stimulus generalization to seizure-eliciting stimuli by this animal model could prove beneficial to the treatment of human epileptics.

DIFFERENCES IN MOTIVATIONAL AND COGNITIVE FACTORS BETWEEN TRADITIONAL AND NON-TRADITIONAL AGE COLLEGE STUDENTS. Teresa M. Dornan and Elaine M. Justice, Dept. of Psych., Old Dominion Univ., Norfolk, VA 23529. Differences in the academic performance of traditional and non-traditional age students were examined to investigate cognitive and motivational variables varying as a function of age and gender, at the college level. Three questionnaires were administered to 95 undergraduate students to determine differences in beliefs regarding memory capacity, motivated self-regulatory learning, study activities, and academic performance. Findings indicated traditional and non-traditional students were significantly different, with respect to age and gender for motivational factors and cognitive study activities. No differences were found between the traditional and non-traditional students for beliefs regarding memory capacity, or actual academic performance.

NARCISSISM AND HOSTILITY. Chet H. Fischer, Dept. of Psychology. Radford University., Radford, Va 24142. The DSMIII-R details the various features associated with Narcissistic Personality Disorder. One important criteria is the narcissist's tendency to become angry when his/her narcissistic needs are frustrated. This has been labeled "narcissistic rage". Numerous researchers and therapists have described this characteristic. McCann and Baggio (1989) focused on hostility in narcissistic subjects and demonstrated that individuals with high narcissism exhibited significantly greater anger arousal than subjects with low narcissism. In the present study, a stronger method of assessing hostility was used. One hundred six subjects were administered the Narcissistic Personality Inventory and the Cook-Medley Hostility Scale. The results demonstrated a strong significant correlation between high NPI scorers and high Cook-Medley scores ($r=.69$ $p<.001$). The present research suggests that narcissistic subjects, rather than exhibiting hostility as a reaction, have a pervasive high level of trait, not state, hostility.

THE USE OF SOCIAL RESPONSIBILITY STATIONS AT UNIVERSITY ALCOHOL PARTIES: A TEST OF INDIVIDUALS' PROPENSITY TO "ACTIVELY CARE". Kent E. Glindemann, Anjali Mohla, Jennifer LaMonica, Mary L. Spiller, & E. Scott Geller. Dept. of Psyc., Va. Tech., Blacksburg, VA 24061. Excessive alcohol consumption on college campuses and concomitant risks for DUI continue despite efforts to reduce their occurrence. This project assessed the validity of a theory-driven "actively caring model," designed to predict individuals who will volunteer to apply intervention techniques to reduce the probability of alcohol-related problems. The research also evaluated the extent that certain verbal report measures of person factors (i.e., specific intentions, risky lifestyles, and certain personality characteristics) predicted levels of alcohol consumption at two fraternity parties. Prior to the two parties, students' drinking intentions and person characteristics were measured. Before and after the parties, students' BAC was assessed with a breathalyzer. During the parties, students' participation in various intervention techniques was systematically observed. Results of the study are discussed, as are implications for preventing the occurrence of DUI.

CLOTHING SELECTION: A TEST OF KELLEY'S ATTRIBUTION THEORY. Amy H. Grimshaw and Barry Gillen*, Dept. of Psychology, Old Dominion University, Norfolk, VA 23529. Kelley's attribution theory was tested in regard to clothing selection. Each of 121 male subjects and 133 female subjects was given two scenario and questionnaire series. The two scenarios described the clothes worn by an individual (Ann/Bill) to a five year reunion party. Each scenario given to experimental subjects included one of eight combinations of high or low consensus, high or low consistency, and high or low distinctiveness information. Each subject was asked to attribute the individual's clothing selection to internal factors, to external factors, or to some combination of each. As predicted external attribution was strengthened by the combined effect of high consensus, high consistency, and high distinctiveness and also by the independent effects of high consensus and high distinctiveness information. Similarly, internal attribution, as expected, was strengthened by the combined effect of low consensus, high consistency, and low distinctiveness and also by the independent effects of low consensus and low distinctiveness.

INTERACTION OF ETHANOL AND CAFFEINE ON RAT MOTOR ACTIVITY. Lester A. Hawkins & Perry M. Duncan, Dept. of Psych., Old Dominion Univ., Norfolk, VA 23508. The Effects of a range of doses of stimulant and depressant drugs and their combination on rat motor activity were observed. Eight long evans male rats were used as subjects. The IVs were ethanol (ETH) at three doses (0, .3, .6, and 1 g/kg), caffeine (CAFF) at two doses (0, 15, and 30 mg/kg), and six 10-minute post-injection time intervals. The DVs were the amount of motor activity, including ambulation, rearing, and total movement. ETH decreased and CAFF increased motor activity in a dose-related manner. ANOVAs revealed that both main drug effects were significant as was the drug interaction. The pattern of results suggest that a low ETH dose potentiated the CAFF effect, possibly due to a combination of disinhibition and arousal-increasing action.

EVENT-RELATED POTENTIALS AND METAPHOR PROCESSING. Charles B. Ireland, Dept. of Psych., Washington and Lee Univ., Lexington, VA. 24450, & Tom P. Urbach, Dept. of Phil., Washington and Lee Univ., Lexington, VA 24450. It is a point of debate whether or not metaphor comprehension requires a special form of linguistic processing. Activity of the human brain during linguistic processing can be studied using event-related potentials (ERP), recorded from the scalp (Kutas, Hillyard 1984). If the processing of metaphor differs from the processing of literal language, then these differences might appear in ERP data. This experiment recorded ERPs in response to reading sentences of three types: metaphorical, literal, and nonsense.

SEXUAL ASSAULT AND ITS IMPACT ON RELATIONSHIP PATTERNS: A DEVELOPMENTAL APPROACH. Kathryn J. Karageorge and Deborah G. Ventis, Dept. of Psychology, College of William & Mary, Williamsburg, VA 23185. Sexual assault, including acquaintance rape, rape by a stranger, and attempted rape, is prevalent among adolescents and young adults and is of major concern for females in particular. Within the past 15 years, several researchers have focused their studies on the psychological effects produced by a sexually coercive incident on the victims. However, few studies have examined this relationship within a developmental framework. This study investigated the current level of emotional and physical intimacy experienced by victims of sexual assault and if the age at which the assault occurred influenced the severity of these effects. A total of 65 female students participated in the study (mean age=18.75). Data analyses revealed that the victims' age at the time of the incident was not significantly correlated with their ability to be emotionally and physically intimate with members of the opposite sex. However, the relationship between victim and offender as well as the level of coercion reported by the victim was significantly correlated with the ability to trust, make friends with, and get close to members of the opposite sex. Future implications will be discussed.

IMPLICIT AND EXPLICIT MEMORY IN CHILDREN. Douglas M. Kaufman, C. E. Southgate*, and D.G. Elmes, Dept. of Psychology, Washington and Lee Univ., Lexington, VA 24450. As children develop their explicit memory increases dramatically. Field studies have indicated that implicit memory is good in young children, nearly as good as that of older children. The present work compared the implicit and explicit memory of children and college students on well-controlled laboratory tasks. Fourth-graders, eighth-graders, and college students were tested on the same implicit task, which was a rule-based sequential reaction-time task. The same subjects were also tested for their explicit free recall of a list of words, which was taken from fourth-grade spelling lists. Implicit memory differed much less across the three age groups than did explicit memory.

FACTORS INFLUENCING THE SUCCESS AND FAILURE OF COLLEGE FRESHMEN. Laura E. Kellard, Raymond H. Kirby, and Peggy A. Herzog-Simmer, Dept. of Psychology, Old Dominion Univ., Norfolk, Va. 23529. The factors influencing the performance of freshmen at Old Dominion University were investigated using qualitative methods. Students had the opportunity to identify and discuss the factors they found affected their academic success. Forty-eight, full-time male and female freshmen participated in one of six focus groups that were conducted. Two groups were academically successful freshmen (with a 3.0 or higher G.P.A.), two groups were academically unsuccessful freshmen (with a 1.99 or below G.P.A.), and two were "mixed" groups having a combination of successful and unsuccessful freshmen. Differences were noted in several factors affecting academic performance reported by the successful and unsuccessful groups. Particularly, goal setting behaviors, effective use of support services, and communication apprehension differed between the successful and unsuccessful groups. This study provides qualitative information which may help illuminate and explain quantitative data previously collected on the freshmen population.

PAVLOVIAN CONDITIONING OF BLOOD GLUCOSE RESPONSE IN RATS. Kristen E. Koontz, and Perry M. Duncan,* Dept. of Psychology, Old Dominion Univ., Norfolk, Va. 23508. It remains unclear as to whether conditioning a rat to a hypoglycemic state will cause a decrease or an increase in locomotor activity. In the current study, 8 rats were conditioned to become hypoglycemic. Insulin (US) was administered for 5 conditioning days. The rats were placed in an activity detector for 30 minutes where their activity was recorded (UR). The odor in the box plus the insulin served as the conditioned stimulus. For the next 3 days, the rats were injected with saline. Blood glucose was measured before and after each conditioning and test day. The analysis of variance revealed that activity level declined over the conditioning days and on the test days. The blood glucose levels increased and decreased at different times. This may have been the result of an insufficient time in the activity detector.

DISPLAYING OF SAFE SEX INFORMATION AT A UNIVERSITY SANCTIONED FRATERNITY PARTY TO EXAMINE THE EFFECTS ON ALCOHOL CONSUMPTION. Kristy L. Maddox, Amy B. Greshenoff, Amie Gee, Brenda R. Wetzel, & Mary L. Spiller, Dept. of Psyc., VA Tech, 5100 Derring Hall, Blacksburg, VA 24061-0436. In our society, safer sex has become an issue of importance. Convincing the college age population of the dangers of being irresponsible when alcohol and sex are combined, however, is a challenge which has yet to be adequately addressed. The present study examined how a Safe Sex, Social Responsibility Information Station set up at a university sanctioned fraternity party would affect research participants Blood Alcohol Concentration (BAC) levels. Information and material available at the station included pamphlets about acquaintance rape, safe sex practices, and alcohol issues, as well as free condoms subjects were allowed to take with them. Relationships between alcohol intoxication levels, participation at the station, and various personality measures are discussed.

Discourse Context Effects in Locally Ambiguous Sentences: Evidence from Event-Related Potentials. Thomas R. Mason and Thomas P. Urbach, Dept. of Psychology, Washington and Lee University, Lexington, VA 24450. The disambiguating word in locally ambiguous "garden-path" sentences is known to elicit a late positive deflection in the event-related potential (ERP). The present study presented garden-path sentences that began with a singular definite noun phrase, e.g., "The patient presented by the doctor was nervous", preceded by a paragraph of text in which either one or two patients were mentioned. The prediction was that the processing difficulty at the disambiguating word, "by", would be greater when the discourse context contained a unique referent. Comparison of the ERPs at "by" showed a significant difference, but with a polarity the reverse of what was predicted. The single discourse referent condition also elicited a significant parietally maximal negativity at the final word which accords with reports from other garden-path studies. These results suggest that the discourse contexts do differentially affect the processing of the locally ambiguous sentence in the disambiguating region but the precise nature of the processing awaits further investigation.

THE CONTINGENT NEGATIVE VARIATION DURING OLFACTORY AND VISUO-SPATIAL LABELING. Douglas C. Matia, J.M. Turner*, & T. S. Lorig, Dept.. of Psychology, Washington and Lee University, Lexington, VA 24450 & S. Warrenburg*, International Flavors and Fragrances, Research and Development, 1515 Highway 36, Union Beach, NJ 07735. Fifteen subjects participated in an experiment designed to assess CNV during the labeling of odors and shapes. Odors or shapes were presented (S1) and followed three seconds later by a lexical label (A,B, or C.) (S2). The label (S2) identified the stimulus correctly in 75% of the trials and incorrectly in the remaining 25% of the trials. Subjects' olfactory ability (CCCRC) was determined and correlated with both the CNV during the S1/S2 interval and also the P300 to the S2 stimulus. Results of these correlations and analysis of variance indicated that the CNV over the left frontal area of the cortex was significantly larger in the olfactory phase of the experiment as conpared with the visuo-spatial phase. CNV activity also correlated with ofactory performance. The data show that subjects with the largest odor-related CNV's had the best olfactory performance. While P300 differed as a function of label matches versus mismatches, no odor specific effects or correlations were found. Results are discussed as to the cognitive processes represented by the left frontal negativity. It is possible that subjects created an intermediate label for the odors which is not available for the shapes. A cognitive manipulation such as this would not necessarily make the task more difficult, only different.

THE ROLE OF VERBALIZATION AND SOCIALIZATION IN PEER TUTORING ACTIVITIES AND CHILDREN'S ABILITY TO LEARN. Suzanne Morrow, Elaine Justice*, & Michael Colbert*, Dept. of Psychology, Old Dominion Univ., Norfolk, Va. 23549. The effects of peer tutoring on third graders' use of an organizational memory strategy was examined. Children were first introduced to the memory task with highly associated items. Children either taught another child the task, tape recorded instructions to give another child, or did the task again. Organizational memory was then retested measuring recall, sorting style, and clustering on low associates. There were no significant differences due to peer tutoring. A significant gender difference was found with males showing higher levels of recall, sorting, and clustering.

THE INFLUENCE OF TASK-UNRELATED THOUGHTS (TUTS) ON VIGILANCE PERFORMANCE. Glenora Nelson & Fred G. Freeman, Ph.D, Dept. of Psychology, Old Dominion University, Norfolk, Va. 23529. Numerous studies have attempted to explain the factors responsible for vigilance decrement. The present study examined the relationship between the propensity to produce task-unrelated thoughts (TUTs) and vigilance performance. Twenty-five subjects participated in a 40-min vigilance task. The Boredom Proneness Scale (BPS) and the Cognitive Failures Questionnaire (CFQ) were used as measures of the propensity to produce TUTs. A correlation analysis of the data failed to show significant relationships between the variables measured; however, the results suggested an inverse relationship between duration of the task and vigilance performance. Further studies employing other measures of individual differences in the ability to sustain attention are needed to better understand the relationship between vigilance performance and the propensity to produce TUTs.

THE EFFECTS OF ATTENTIONAL DEMANDS ON PERFORMANCE RATINGS OF WOMEN AND MEN IN TRADITIONALLY FEMALE AND MALE OCCUPATIONS. Beth Parsons and Glynn D. Coates, Dept. of Psychology, Old Dominion University, Norfolk, VA 23529. Previous research notes that various factors affect performance appraisals. This present study specifically examined the factors of attentional demands and gendered occupations and their impact on performance appraisals. Thirty-two subjects read vignettes of male and female police officiers, and male and female nurses. Subjects rated the incumbent's work performance. Heightened attentional demands were imposed on the experimental group. Research has indicated heightened attentional demands lead to discrimination. As predicted no interaction of attentional demand was present. Thus, the basis for heightened attentional demands resulting in discrimination was not supported in this study. Of interest was the interaction of the gendered occupation and gender of the incumbent. Male nurses were rated higher in work performance than females. This role reversal held true for police officers also.

HOW ENVIRONMENTAL DIFFERENCES IN UNIVERSITY DINING HALLS AFFECT EMPLOYEES' "ACTIVELY CARING" BEHAVIORS. Olga Patarroyo, Kimberly Nuttycombe, D. Steve Roberts, Craig Martin, & Amy B. Gershenoff, Dept. of Psyc., VA Tech., Blacksburg, VA 24061. Actively Caring (AC) is defined as going beyond the call of duty to benefit others or the environment (Geller, 1992). A refined version of the AC Survey was given to employees in two Dining Halls to measure the person factors (e.g.,self-esteem, empowerment, and belonging) related to the employees' propensity for AC as well as the extent to which employees are willing, feel they should, and do AC (Geller, Roberts, & Gilmore, 1993). An AC behavior checklist was used to evaluate employees' AC and non AC behaviors. The factors considered fell into three domains: person, environment, and behavior focused AC. The hypothesis, based on the senior author's previous work experience at both Dining Halls and knowledge of the AC model, is that Dining Hall B employees will have a higher propensity to Actively Care. Results and further implications will be discussed.

RELATIONSHIP BETWEEN CIRCADIAN PERIOD AND SEIZURE EXPRESSION IN THE MONGOLIAN EPILEPTIC GERBIL(*Meriones unguiculatus*). Jennifer J. Peszka & J.W. Collins, Dept. of Psychology, Washington & Lee University, Lexington, VA 24450. Mongolian epileptic gerbils were tested in the open palm once a day for six weeks every four hours in an attempt to establish the daily periodicity of their seizures. Daily periodicity has been established for epilepsy in humans (diurnal) and rats (nocturnal). Because the gerbil is considered diurnal, it was expected that the activity rhythms of the gerbil would more closely resemble those of the human than the rat. By implication any periodicity in seizure expression of gerbils should more closely match that of the human. No significant time of day effect was found for seizure expression. However, there was a trend towards this effect. A significant decrease from expected seizure expression occurred at the 8:00 P.M. testing time. This did not follow the original hypothesis that seizure incidence would increase during this time. Further research into the activity period of the gerbil is needed to counter this discrepancy.

ALCOHOL TESTING THROUGH COGNITIVE BEHAVIORAL FITNESS TESTS. Charles B. Pettinger, Jr., Michael J. Kalsher, D. Steve Roberts, & Kent E. Glindemann, Dept. of Psyc., VA Tech, Blacksburg, VA 24061. Dependence on alcohol and other drugs is America's most common psychological condition and extends into the workplace. There have been inconsistent findings regarding the impact of alcohol and other drugs in terms of measurable outcomes in the workplace. The present study tested the sensitivity of a battery of tasks (termed Compensatory Tracking Task Battery, CTTB) to decrements in participants' performance under the influence of alcohol at a fraternity social event. The CTTB is comprised of a questionnaire and three variations of the Compensatory Tracking Task (CTT). After each subject developed a personal baseline on the CTTB, they provided a breathalyzer sample and completed between 4-8 sets of the CTTB at the social event. The study was conducted to determine whether the variations of the three CTT would improve the detection of decrements in subjects' cognitive/behavioral fitness over the CTT alone. Relevant results and implications to drug screening in the workplace will be presented and discussed.

THE EFFECTS OF PREMATURE BIRTH ON MATERNAL STRESS DEPRESSION AND MOTHER-INFANT INTERACTION. Daniel M. Phillips III and Michelle L. Kelley Ph.D.*, Dept. of Psychology, Old Dominion Univ., Norfolk, VA, 23529. Parenting of premature infants has been associated with increased levels of maternal stress and depression. Decreased levels of mother-infant interaction followed by overstimulating maternal behavior have also been found within the first year of these infants' lives. This research attempted to replicate previous findings using the Parenting Stress Index and Beck Depression Inventory scales. The groups in comparison were 36 mothers of 5-month-old full-term infants and 34 mothers of 5-month-old adjusted age very low birthweight (VLBW) infants. Previous mother-infant interactive differences were also attempted to be replicated. However, the CARE-Index, a recently developed scale of mother-infant interaction, was used to reduce the influence of situation specific aspects of the interaction and maximize the influence of the mother and infant's expectations of one another. Findings demonstrate significantly higher levels of parenting stress associated with VLBW infants. Overstimulating interactive behavior also was observed in mothers of premature infants. However, full-term mothers reported higher levels of depressive behaviors. In conclusion, it is suggested that future educational intervention programs may prepare mothers of VLBW infants for the stresses and difficulties associated with their parenting.

INTRAHEMISPHERIC INTERFERENCE OF EMOTIONAL STIMULI AS A FUNCTION OF HAND USED, SEX, EAR OF INPUT, AND TASK DIFFICULTY ACROSS MOTOR AND COGNITIVE TASKS. Lawrence J. Prinzel III, & Frederick G. Freeman, Dept. of Psychology, Old Dominion Univ., Norfolk, Va. 23529. The effects of intrahemispheric interference on reaction times and accuracy were examined. A dichotic-listening task was presented to subjects that consisted of identifying an angry emotional target. For each subject, four trials were presented that varied in hand used for responding, motor difficulty, and the absence or presence of a white noise. The results evinced that intrahemispheric interference was reduced when a simple go/no-go motor response was employed relative to a more complex, two-choice motor response. These results confirmed earlier studies that showed similar findings. Subjects also responded faster when the left-hand was used for motor response and also when stimuli were inputed in the left ear, but not when white noise was presented in the background. Significant interactions were found for mean reaction times for hand used by motor condition, and for hand used by motor condition by cognitive condition. A marginally significant interaction for hand used by motor condition by ear of input was also found for mean reaction times. These results suggest that an increase in response processing demands increase right-intrahemispheric interference. A significant main effect was also found for sex for both mean reaction times and mean number of correct responses. The results were interpreted as stemming from differences in performance strategies between males and females.

HOW SELF-ESTEEM EFFECTS THE AMOUNT OF ALCOHOL UNIVERSITY STUDENTS CONSUME: A FIELD STUDY. Kareen L. Ramsby, Kristy L. Maddox, John P. Jones, III, Jamie Spisak, & Thomas E. Boyce, Dept. of Psyc., VA Tech, 5100 Derring Hall, Blacksburg, VA 24061-0436. Previous research has found that low self-esteem is a motivator for alcohol use because it provides positive feelings of self worth. Therefore, considering the large quantity of alcohol comsumed by college students, it has been implicated that many college students who drink have low self esteem and a sense of unbelongingness. In this study, approximately 100 college students were randomly selected to complete a questionnaire pertaining to self-esteem and belongingness. These students then volunteered to have their BAC taken at a party which involved alcohol consumption. Relevant results are discussed, along with implications for preventing alcohol-related problems among college students.

A PSYCHO-MOTOR SOBRIETY TEST: OPEN STRATEGY VERSUS SPECIFIED STRATEGY. C. Matt Rashleigh, Kent E. Glindemann, Jeff Ammons, Jennifer Heath, & Soo Kang, Dept. of Psyc., VA Tech, 5100 Derring Hall, Blacksburg, VA 24061-0436. In applied behavioral research it is important to operationally define the behaviors to be observed. It is also important to specify what is expected from the subjects in order to achieve uniformity of behavior. In this way, there is more confidence that variances in behavior are due to the independent variables and not due to varying methods used in carrying out the behavior. This study focuses on the format in instructions given to subjects before the completion of a sobriety test (The Star Tracing Task). In the control condition, subjects were not given a strategy to be used in completion of the task. In the experimental condition, subjects were given a unifying strategy to be used while completing the task. Results are discussed along with implications towards reducing driving while intoxicated.

GOAL-SETTING AND SELF EFFICACY IN AMATEUR ATHLETES. Monica A. Rickard and Raymond H. Kirby, Dept. of Psychology, Old Dominion University, Norfolk, VA 23529.

The purpose of this study was to investigate the relationship between self-efficacy and goal setting in runners, and whether reaching or failing to reach the goal had any affect on self-efficacy. Runners participating in 5K races were questioned about their goals for the upcoming race and their self-efficacy was assessed both prior to and following the race. It was found that runners with higher self-efficacy set higher goals. However no difference was found in post-race self-efficacy scores between subjects that reached their goals, and those that did not. It was also found that subjects who spontaneously set goals without prompting tended to do better relative to their past performance than subjects who had to be prompted to set a goal.

INCREASING STAIR SAFETY ON A UNIVERSITY CAMPUS: A COMPARISON OF FIELD TESTS. D. Steve Roberts, E. Scott Geller, Kristy L. Maddox, & W. Geoffery Fitch, Dept. of Psyc., VA Tech., Blacksburg, VA 24061. People often disregard safety messages that focus on self-protection. However, other-focused messages may give people the more realistic belief that someone will be injured and their safe behaviors could help others by setting a safe example. This study included two field tests to assess the relationship between the content of a safety message and hand rail use on a university campus. In addition to a baseline (i.e., no sign) condition, both field tests included three sign conditions posted in university stairwells. One type of sign read "Please Hold the Handrail When Going Up and Down Stairs". Another type of sign read "Caution! Stairs May be Wet -- Please Hold the Handrail When Going Up and Down Stairs". The final type of sign read "Set a Safe Example for Others -- Please Hold the Handrail When Going Up and Down Stairs". In the first feild test, areas where the "example" sign was presented showed the largest increase in handrail use over baseline (from 33% to 51%). Results from the second feild test will be compared to the first and discussed in terms "actively caring" for others as a motivator for safety.

UNDERGRADUATE PERCEPTIONS OF CLINICAL PSYCHOLOGY IN COMPARISON TO NON-PROFESSIONAL, ALTERNATIVE METHODS OF CONSULTATION. Susan P. Sherburne & Louis H. Janda, Dept. of Psyc., Old Dominion Univ., Norfolk, Va. 23529. Undergraduates' perceptions of clinical psychology were measured in comparison to those of clergy, "psychics," and friends/family members as caregivers. Sixty-four females and 64 males read brief scenarios, varying according to type of caregiver and magnitude of problem for which help was received (low, moderate, high). Subjects rated caregiver according to status, competency, effectiveness, skills possessed beyond the average person, and deserved fee for services. Five 4x3x2 mixed ANOVAs revealed main effects for both consultant type and magnitude of problem, indicating a significant difference between "psychics" and the other methods of consultation on the dimensions of status, competency, and effectiveness, as well as a difference between clinical psychology and the other methods on deserved fee for services. These findings suggest that clinical psychology is not necessarily a preferred method of treatment, lending to the notions of psychology as "common sense" and suggesting that psychologists offer no more than the average person.

CHOICE REACTION TIME USING CONSISTENT AND VARIED MAPPING OF STIMULI. Steven M. Springer and Glynn D. Coates, Dept. of Psychology, Old Dominion University, Norfolk, VA 23508. This study examined the effects of consistent and varied mapping of letters on choice reaction time and to determine if the Hick-Hyman law, which states that reaction time increases as the amount of information transmitted increases, applies to intersection decisions during consistent and varied mapping conditions. In the consistent mapping condition, subjects had to determine if all members of the positive set were shown in the display set while the positive set was constant for each trial. In the varied mapping condition, subjects had to perform the same task while the positive set was different for each trial. Results found that reaction time was significantly longer for varied mapping conditions, suggesting that serial processing was used for varied mapping conditions and parallel processing for consistent mapping conditions. Reaction time significantly increased for varied mapping conditions as the size of the positive set increased, suggesting a similar function to the Hick-Hyman law. This effect was not found for consistent mapping conditions, but the trend was in the correct direction.

RE-ENCODING SPECIFICITY IN HUMAN MEMORY. Todd H. Stanton, M.R. Saunders*, and D.G. Elmes, Dept. of Psychology, Washington and Lee Univ., Lexington, VA 24450. What is it that people remember when they attempt to recognize a target item? At least one thing that they remember is what has been rehearsed. If the match between what is learned and what is remembered is important--encoding specificity--then it is likely that the match between what is rehearsed and what is remembered is important--re-encoding specificity. The results of several experiments suggest that hearing a target item in a voice that is similar to your own voice enhances the recognition of the target if it is also heard in that voice during the recognition test. The implications of re-encoding specificity will be discussed.

THE EFFECTS OF LAMOTRIGINE ON SEIZURE EXPRESSION IN KINDLED MONGOLIAN GERBILS (Meriones unguiculatus). Karen L. Stutzmann, D.N. Bryant, & J.W. Collins, Dept. of Psychology, Washington & Lee University, Lexington, VA 24450. Mongolian gerbils are seizure susceptible and the seizure expression is readily kindled to a desired stimulus. This makes them suitable candidates for the testing of antiepileptic drugs (AEP). Lamotrigine (LTG), a relatively new AEP, has been noted for its ability to reduce the seizure severity of epileptic humans without producing the adverse side effects that frequently accompany the administration of other AEPs. The effects of various LTG dosages (1mg/kg, 5mg/kg, and 10mg/kg), delivered via i.p. injection, on seizures at one half hour and one hour post-injection times revealed that LTG significantly reduces seizure severity. LTG reduced seizure frequency at the one half hour, but not at the one hour post-injection time. These results suggest that LTG works by inhibitiing seizure spread from the focus, but not by actively blocking seizure occurrence.

Event-Related Potentials and Syntactic Priming in Locally Ambiguous Sentences. Laura Ashley Myler and Thomas P. Urbach, Dept. of Psychology, Washington and Lee University, Lexington, VA 24450. Priming effects are well attested in lexical processing but less is known about priming for grammatical structure in sentence processing. The present study examined syntactic priming effects in the processing of locally ambiguous "garden-path" sentences. The S2 garden-path target sentences were preceded by S1 which was either a different garden-path sentence with the same structure or a control sentence. The prediction was that the processing difficulty of the primed targets would be reduced. Event-related potentials (ERPs) recorded on-line are known to be sensitive to the processing difficulty in garden-path sentences, and in particular, the disambiguating word elicits a characteristic late positive deflection in the ERP. Comparison of the ERPs in S1 showed that the garden-path items elicit the expected positivity relative to their controls. Comparison at the S2 garden-path target showed that the positivity was reduced in the primed condition, supporting the hypothesis that the processing difficulty is reduced.

"ACTIVELY CARING AND ALCOHOL CONSUMPTION: A FIELD STUDY OF COLLEGE STUDENTS. Jaime B. Wheeler, Charles B. Pettinger, Jr., Christopher Saunders, Ivan O. Haskell, & Tammy B. Shurts, Dept. of Psyc., 5100 Derring Hall, VA Tech, Blacksburg, VA 24061-0436. The Actively Caring Model and Alcohol Consumption hypothesis were tested by asking subjects to complete two types of evaluation. Two groups of college students (one fraternity, one sorority), participated in a university sanctioned social event. Subjects were asked to complete two standardized tests prior to the social. The Actively Caring Survey (Geller, 1993) and an opinion questionnaire were used to measure individual differences in attitudes and ideas related to involvement in social settings, and alcohol consumption. Test results were correlated with actual Blood Alcohol Concentration (BAC) during the social. Relevant findings and ideas for future research in this area are discussed.

Statistics

SOME COMMENTS ON PEARSON AND TIKU'S WORK RELATING THE CENTRAL AND NON-CENTRAL F DISTRIBUTIONS. James M. Davenport, Dept. of Math. Sciences, Va. Commonwealth Univ., Richmond, VA. 23284-2014. Professor Egon S. Pearson of University College London visited the department of statistics at Southern Methodist Univ. on March 28, 1969. He consulted with faculty and gave a lecture to graduate students, faculty and invited guests; the title of his presentation was "Some Historical Reflections, Traced Through the Development of the Use of Frequency Curves." The primary result is the development of Karl Pearson's system of frequency curves, which is typically displayed via the familiar (β_1, β_2) plane (that is, the skewness and kurtosis parameters). This presentation reviews this historical development through Pearson and Tiku's paper (1970, *Biometrika*, 57, p.175-9), where they indicate that the (β_1, β_2) points for the non-central F distribution lie inside the Type VI region of Pearson's curves. It is demonstrated, for large degrees of freedom in the denominator, that the (β_1, β_2) points of a non-central F lie within the Type I region of Pearson's system. This result impacts the use of Pearson's curves in 4-moment approximations.

FISHER INFORMATION FOR LOCATION AND SPLINE ROOTGRAM ESTIMATION, Clark K. Gaylord, Department of Statistics, Virginia Polytechinic Institute and State University, Blacksburg, Va 24063. A non-parametric estimate of Fisher information for location is developed using linear B-spline root-density, or "rootgram," estimates. This method also provides a density estimate. A test of normality is derived that is shown via simulation to be comparable to, and sometimes superior to, the Shapiro-Wilk test, a popular test of normality.

DELETION, AUGMENTATION AND PRINCIPAL PREDICTORS. Donald R. Jensen, Dept. of Statistics, Va. Polytechnic Inst. & State Univ., Blacksburg, VA 24061. Effects of design augmentations and deletions are studied analytically as comparative Fisher efficiencies in estimation, Pitman efficiencies in hypothesis testing, and predictive efficiencies at points in the design space. Linear parametric functions most harmed by deletion and most enhanced by augmentation are identified and related to prediction at a point. Effects of augmenting or deleting sets of points are characterized using principal components of the predictive dispersion at those points. Coefficients of the affected parameters are given explicitly in terms of the points of augmentation or deletion. Eight small second-order designs are studied in detail with supporting numerical displays. Comparisons are drawn to other approaches from the literature.

TEST FOR NON-ZERO CORRELATION IN CONTINGENCY TABLES. Robert E. Johnson and Yong Zhu*, Department of Mathematical Sciences, Division of Operations Research and Statistics, Virginia Commonwealth University, Richmond, VA, 23284-2014. Hypothesis tests concerning Kendall-type correlation between ordinal variables are well known for the hypothesis of independence, but not for the hypothesis of zero correlation. Two procedures, one by Brown and Benedetti and one by Goodman and Kruskal, have been proposed to approximate the asymptotic standard error of the sample correlation measure. Problems with these approximations and a new estimator based on a combination of these approximations are examined. The estimators are compared to both the asymptotic standard error and the true standard error using the maximum likelihood estimates of cell probabilities with the constraint of zero correlation. A Monte Carlo procedure is used to generate sampling distributions.

A PROCEDURE FOR COMPARING EXPERIMENTS BASED ON A MEASURE OF SUFFICIENCY (PRELIMINARY REPORT). Patty Kitchin & Robert V. Foutz*, Dept. of Statistics, Va. Polytechnic Inst. & State Univ., Blacksburg, VA 24061. Often it is necessary to choose between two or more experiments or two or more statistics within the same experiment. One approach to this problem is to measure the amount of information about the parameter space provided by each experiment or each statistic and make a decision based on the information measure. However, the more common information measures such as Fisher's information and the Kullback-Leibler information function are only useful under certain assumptions. A new measure that provides a solution where other measures are not informative will be introduced along with some examples and preliminary results.

IMPROVING THE W50 TEST FOR EQUALITY OF SPREAD. R. H. Lamb, Dept. of Math. Sciences, Va. Commonwealth Univ., Richmond, VA 23284-2014. The Brown-Forsythe W50 test is a robust test for equality of spread in independent groups. While generally highly regarded, it however yields extremely conservative tests for small odd sample sizes. Two methods are discussed for improving the W50 test in these situations. Monte Carlo results are presented which illustrate and contrast the improvement due to each method for several sample sizes.

A NEW REPRESENTATION FOR BINARY-VALUED TIME SERIES DATA IN THE FREQUENCY DOMAIN. Hoonja Lee, Dept. of Statistics, Va. Polytech. Inst. & State Univ., Blacksburg, VA 24061, & Robert V. Foutz, Dept. of Statistics, Va. Polytech. Inst. & State Univ.,Blacksburg, VA 24061. The Classical Fourier analysis of time series data can be used to detect periodic trends that are of sinusoidal shape. However, this analysis can be misleading when time series trends are not sinusoidal. In this paper, we develop theory and methods that can be applied to binary-valued data where patterns more naturally follow a rectangular shape. The theory parallels the Fourier theory and leads to a "Fourier-like" data transform that is specifically suited to the identification of rectangular trends.

A PROCEDURE FOR ESTIMATION OF PARTIAL GROUP DELAY (PRELIMINARY REPORT). Milan Mangeshkar & Robert V. Foutz*, Dept. of Statistics, Va. Polytechnic Inst. & State Univ., VA 24061. Partial group delay has an interpretation as the time-lag between two channels of a multiple time series after adjustments have been made for the influence of the remaining channels. A two stage methodology is proposed in the spectral domain for estimating the group delay at a frequency of interest. In stage I preliminary values of the group delay are estimated, and in stage II the preliminary values are simultaneously transformed and modeled to obtain an estimate of the mean of the preliminary values (in original units). This estimate is uniformly minimum variance unbiased provided the periodogram and cross periodogram ordinates at each Fourier frequency are independent of the periodogram and cross periodogram ordinates at all other Fourier frequencies. The procedure will be introduced and demonstrated using a simulation study. The preliminary results obtained for the proposed methodology will be compared to the results obtained using an existing procedure.

D- AND Q-OPTIMAL FACTORIAL DESIGNS IN THE PRESENCE OF DISPERSION EFFECTS. Darcy P. Mays, Dept. of Mathematical Sciences, Va. Commonwealth Univ., Richmond, VA 23284-2014, & Stephen Easter*, Dept. of Mathematical Sciences, Va. Commonwealth Univ., Richmond, VA 23284-2014. Traditional response surface methodology experimental designs for estimating location models involve the assumption of homogeneous variance throughout the design region. However, with heterogeneous variance these standard designs are not optimal. The D- and Q-optimality criteria will be used to find the optimal designs for different levels and types of heterogeneous variance. Tables of optimal designs will be presented and used to show the relative inefficiencies of the standard designs. The conclusions will suggest the need for an alternative procedure that will estimate the variance structure and use it to obtain a better estimate of the location model.

COMPROMISE ON PROTECTION FOR MODEL MISSPECIFICATION. Young Moon, Dept. of Statistics, Va. Polytechnic Inst. & State Univ.,Blacksburg, VA 24061. The model misspecification and its robustness has always been a serious objection to the utilization of superpopulation models in finite populations. Instead of imposing restrictions on choosing samples to make the working model as robust to bias, we select a optimal model among the choice of models by Bayes factor. With the chosen model, we design optimally in the sense of minimizing the posterior variance. Without deemphasizing the role of either design or model-based probability sampling, we develop two stages scheme which can be used profitably to protect from model misspecification by compromising between design and model-based approach. Some properties like unbiasedness and mean square error of the derived predictors are studied. An empirical investigation, based on a simulated population, is made to compare the performance of the suggested predictors.

COMPUTING THE SIZE OF A CONFIDENCE REGION. Donald E. Ramirez, Dept., of Math., University of Virginia, Charlottesville, VA 22903. A geometric approach to compare design efficiencies is given for linear models. Using a recent ACM algorithm for computing the surface measure of an ellipsoid, an omnibus geometric criterion for optimal designs is discussed. Comparisons to the A-optimality and D-optimality criteria are demonstrated with selected second-order designs.

A NONLINEAR STATE-SPACE MODEL OF CHINOOK SALMON POPULATION DYNAMICS. Steven R. Rein, Dept. of Math. Sciences, Va. Commonwealth Univ., Richmond, VA 23284-2014. We present a nonlinear state-space model of the population dynamics of the Chinook salmon of the San Joaquin River system in CA. In this model, an unobserved state vector comprised of the number of Chinook in each adult age group along with the number of spawning adults is assumed to evolve in a Markovian fashion. In the model, we emphasize a relationship key to the management of the salmon fishery, that between the number of spawning salmon and the number of their offspring that reach maturity (these we call recruits). Because of an assumed relationship between the survivability of the young salmon (smolts) and springtime water flow, we allow this spawner-recruit relationship to be moderated by flow. We then suggest a method which we call the generalized Kalman filter (GKF), for estimating the parameters of such nonlinear state-space models via maximum likelihood. In the GKF, the distributions of the unknown state, and hence, the likelihood, are approximated numerically. We then apply this GKF to our model of the San Joaquin Chinook salmon to estimate the parameters of the spawner-recruit relationship jointly with the yearly recruit series.

1994 BEST STUDENT PAPER AWARDS

AERONAUTICAL AND AEROSPACE SCIENCES

Michelle T. Martuccio (co-recipient)

George Washington University, Joint Institute for the Advancement of Flight Science, NASA-Langley Research Center. A Wind Tunnel Investigation of the Effects of Micro-Vortex Generators on the High-Lift Characteristics of a Business Jet Wing.

Jennifer L. Burt (co-recipient)

Flight Deck Research Branch, NASA-Langley Research Center. An Evaluation of the Perceived Urgency of Auditory Warning Signals.

AGRICULTURE, FORESTRY, AND AQUACULTURE

T. C. Muller

Dept. of Biology, Virginia Commonwealth University. Assessing Temporal and Spatial Genetic Variation Within American Shad (*Alosa sapidissima*) Populations of Chesapeake Bay Rivers.

ARCHAEOLOGY

Ronald W. Fuchs II

Dept. of Anthropology, College of William and Mary. Archaeological Investigations at a Late Woodland/Early Colonial Site in Gloucester County, Virginia.

ASTRONOMY, MATHEMATICS, AND PHYSICS

J. T. Seo

Dept. of Physics, Hampton University. Discharge Circuit Improvement for Hard-Core Flashlamp Blue-Laser System.

BIOLOGY

Hope S. Thompson (for oral presentation)

Dept. of Biology, Randolph-Macon College. Effect of Prenatal Exposure to Levo-Norgestrel or Ethenyl Estradiol and Norethindrone on Testis Development in CD-1 Mice.

Oliver Bauer (for poster presentation)

Dept. of Biology, Shenandoah University, Comparison of Wing Morphology of Bats on Dominica.

BOTANY

Philip M. Sheridan

Dept. of Biology , Virginia Commonwealth University. Genetics of Aberrant *Sarracenia* Leaf and Flower Color.

EDUCATION

Beatrice Taylor

Depts. of Education and Biology, Virginia Polytechnic Institute and State University. Perspectives on Collaboration in an STS Landfill Restoration Project: Scientist, Classroom Teacher, and Researcher.

ENVIRONMENTAL SCIENCE

Kelly M. Alexander

Dept. of Biology, Chemistry, and Environmental Science, Christopher Newport University. Methane Emissions Associated with *Sagittaria graminea* Michz., Arrowhead, under Enriched Atmospheric CO_2.

GEOGRAPHY

Amy B. Cohen and **Dominic Pisciotta** (co-recipients)

Dept. of Geology and Geography, James Madison University.

Spatial Distribution of Hispanics in the City of Harrisonburg, Virginia.

GEOLOGY

Anita A. Williams

Dept. of Geographv and Earth Systems Science, George Mason University. Sediments of Gunston Cove, Potomac River, Virginia.

MATERIALS SCIENCE

Kevin C. Stewart

Dept. of Materials Science, University of Virginia. Modelling of Crevice Chemistry.

PSYCHOLOGY

Kathryn J. Karageorge

Dept. of Psychology, College of William and Mary. Sexual Assault and Its Impact on Relationship Patterns: A Developmental Approach.

STATISTICS

Milan Mangeshkar

Dept. of Statistics, Virginia Polytechnic Tinstitute and State University. A Procedure for Estimation of Partial Group Delay.

HONORABLE MENTIONS

AERONAUTICAL AND AEROSPACE SCIENCES

Wayne D. Carlsen

George Washington University, Joint Institute for the Advancement of Flight Sciences NASA-Langiey Research Center. Comparison of USM3D and Experiment: How Well Does an Euler Code Predict Transonic Drag Rise?

Christine Schleicher

Dept. of Aerospace Engineering, Old Dominion University. Application of a Higher-Order Theory to Orthotroopic and Laminated Beams.

ARCHAEOLOGY

Suanna C. Selby

Archaeology Department, Mount Vernon Ladies' Association, Mount Vernon, VA 22121. The Dogue Run Survey: Searching for George Washington's Sixteen-sided Barn.

ASTRONOMY, MATHEMATICS, AND PHYSICS

Richard G. Grant

Department of Physics, Old Dominion University. Identification of the Iron-Zinc Phases in Commercially Produced Galvannealled Steel.

Tae H. Kimn

Department of Physics, Old Dominion University. Mossbauer and X-Ray Study of the Iron Nitride, Fe_4N.

BOTANY

Kathryn S. Tolliver

Dept. of Biology, Virginia Commonwealth University. Potential Allelopathic Effects of *Myrica cerifera* on *Pinus taeda*.

David Seaborn

Dept. of Biological Sciences, Old Dominion University. Annual Phytoplankton Dynamics in the Pagan River, Virginia.

EDUCATION

Kenneth Lawwill

Fairfax County Schools, Chantilly High School. Encouraging Question Asking and Writing in the Science Classroom.

ENVIRONMENTAL SCIENCE

Keitha M. Dattilo

Biology Department, Mary Washington College. Isoiation of Kerosene-Degrading Bacteria from Kerosene-Contaminated Soil.

Donald Morgan
Biology Department, George Mason University. Effects of Watershed Urbanization on Stream Fish Communities in Prince William County, Virginia.

GEOGRAPHY
Matthew J. Humke
Dept. of Geology and Geography, James Madison University. Environmental Assessment of the Riparian Zone of the South Fork of the Shenandoah River, Va.

GEOLOGY
Roger Decker
Dept. of Geology and Geography, James Maddison University. Hydraulic Conductivity and Retention of Hydrocarbon Fuel in Soils.

Patricia I. Autrey
Dept. of Geology, College of William and Mary. Hydrogeochemistry of Travertine Deposition at Burwell's Bay in Isle of Wight County, Virginia.

MATERIALS SCIENCE
Martin H. Ettenberg
Dept. of Materials Science, University of Virginia. Characterization of Ohmic Contact Solders to High Performance Thermoelectric Materials for Cooling Applications.

PSYCHOLOGY
Lawrence J. Prinzel III
Dept. of Psychology, Old Dominion University. Intrahemispheric Interference of Emotional Stimuli as a Function of Hand Use, Gender, Ear of Input, and Task Complexity Across Motor and Cognitive Tasks.

Douglas M. Kaufman
Dept. of Psychology, Washington and Lee University. Implicit and Explicit Memory in Children.

Monica A. Rickard
Dept. of Psychology, Old Dominion University. Goal Setting and Self-Efficacy in Amateur Athletes.

AWARDS PRESENTED DURING THE VIRGINIA JUNIOR ACADEMY OF SCIENCE MEETING

AGRICULTURAL AND ANIMAL SCIENCE

Honorable Mention:	Mariesela R. Rodriguez	Matoaca High School
Honorable Mention:	Kathryn C. Norment	Lafayette High School
Honorable Mention:	Adam T. Moore	Chickahominy Middle School
Third Place:	Jennette M. Gayer	H.B. Woodlawn
Second Place:	Jennifer M. Jordan	Gloucester High School
First Place:	Brian M. Green	Yorktown High School

ANIMAL BEHAVIOR (ETHOLOGY)

Honorable Mention:	Lara K. Woolwine	Southwest Va. Governor's S.
Honorable Mention:	Alex Garris	Governor's School for Gov't. & International Studies
Honorable Mention:	Brian M. Curtis	Gloucester High School
Third Place:	Amy J. Bucher	Governor's School for Gov't. & International Studies
Second Place:	Katherine E. Lorentz	Ferguson High School
First Place:	Raven L. Louk	Gloucester High School

BOTANY 'A'

Honorable Mention:	Kevin J. Will	H.B. Woodlawn
Honorable Mention:	Jennifer T. Wilkinson	Midlothian High School
Honorable Mention:	Katherine I. Shrieves	Dozier Middle School
Third Place:	Amol K. Tripathi	Tuckahoe Middle School
Second Place:	Siddhartha G. Shukla	Washington-Lee High School
First Place:	John S. Will	Wakefield High School

BOTANY 'B'

Honorable Mention:	Rudy A. Richter	Thomas Jefferson Middle S.
Honorable Mention:	Kimberly S. Philley	Washington-Lee High School
Honorable Mention:	Patrick S. Moran	Atlee High School
Third Place:	Elizabeth A. Rezba	Monacan High School
Second Place:	Flora M. Perozzi	Hermitage High School
First Place:	Alison H. Mollick	Warwick High School

BOTANY 'C'

Honorable Mention:	Vinay Jain	Governor's School for Gov't. & International Studies
Honorable Mention:	Bethany R. Hankins	Southwest Va. Governor's S.
Honorable Mention:	Liem T. Ha	Wakefield High School
Third Place:	Irena R. Hollowell	Williamsburg Middle School
Second Place:	Suzanne F. Kirby	Southwest Va. Governor's S.
First Place:	Meredith A. Meyer	Washington-Lee High School

BOTANY 'D'

Honorable Mention:	Sophia A. Esterman	Washington-Lee High School
Honorable Mention:	Amanda G. Bock	Gildersleeve Middle School
Honorable Mention:	Ryan F. Agnew	Washington-Lee High School
Third Place:	Craig Gallaer	Poquoson Middle School
Second Place:	Tarah R. Allen	Midlothian High School
First Place:	Ian G. Frick-Tordella	H.B. Woodlawn

CHEMISTRY 'A'

Honorable Mention:	Barbara L. Wasserman	Tuckahoe Middle School
Honorable Mention:	William C. Topham	Midlothian High School
Honorable Mention:	Anant K. Paravastu	Thomas Jefferson High School for Science and Technology
Third Place:	Richard G. Starck, iii	Yorktown High School
Second Place:	Michael B. Marean	Williamsburg Middle School
First Place:	Aditya N. Seth	Thomas Jefferson High School for Science and Technology

CHEMISTRY 'B'

Honorable Mention:	Creighton T. Hager	Thomas Jefferson High School for Science and Technology
Honorable Mention:	Richard K. Bennett, jr	The Collegiate Schools
Third Place:	Micah L. Higgins-Rice	Gloucester High School
Second Place:	Lauren A. Cayton	Thomas Jefferson High School for Science and Technology
First Place:	Melissa C. Cutter	Magnet High School for Science and Health Professions

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Honorable Mention:	Rex K. Min	New Horizons Governor's S.
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Second Place:	Peter B. Gonzalez	Monacan High School
First Place:	Valentin I. Spitkovsky	Lafayette High School

CONSUMER SCIENCE 'A'

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Honorable Mention:	Russell S. Taylor	Poquoson Middle School
Honorable Mention:	Peter A. Murrer	Gildersleeve Middle School
Third Place:	Mary C. Moore	Yorktown High School
Second Place:	Kimberly S. Robbins	Gloucester High School
First Place:	Meg Y. Wang	Harry F. Byrd Middle School

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Honorable Mention:	My'chael D. Jefferson	Meadowbrook High School
Honrable Mention:	Jessica M. Drummond	Williamsburg Middle School
Third Place:	John P. Johnston	Governor's School for Gov't. & International Studies
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First Place:	Vishal Jain	Atlee High School

CONSUMER SCIENCE 'C'

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EARTH AND SPACE SCIENCE

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ENVIRONMENTAL SCIENCE 'A'

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Honorable Mention:	June Zhu	Cave Spring High School
Honorable Mention:	Shelly A. Whitehurst	Lee-Davis High School
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Honorable Mention:	Heather M. Smith	Gloucester High School
Honorable Mention:	Kathryn M. Paulson	Ferguson High School
Honorable Mention:	Diaming Pa	Wakefield High School
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First Place:	Jeffrey H. Scarano	Yorktown High School

ENVIRONMENTAL SCIENCE 'C'

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First Place:	Alan P. Moore	Gloucester High School

ENVIRONMENTAL SCIENCE 'D'

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Honorable Mention:	Daniel C. Daum	Patrick Henry High School - Roanoke
Third Place:	Douglas F. Hobbs	Atlee High School
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First Place:	Catherine T. Airey	Roanoke Valley Governor's S.

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Honorable Mention:	Kerrie B. Lee	Southwest Va. Governor's Sch.
Honorable Mention:	June M. Pearson	Atlee High School
Third Place:	Tu-Anh Thi Bui	Washington-Lee High School
Second Place:	Kabir Yadav	Thomas Jefferson High School for Science and Technology
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MATHEMATICS AND STATISTICS 'B'

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Honorable Mention:	Shelley D. Miller	Turner Ashby High School
Honorable Mention:	Trinh N. Lieu	H.B. Woodlawn
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Second Place:	Laura L. Mehlinger	H.B. Woodlawn
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ZOOLOGY 'B'

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Honorable Mention:	Jeremy W. Mckenna	Patrick Henry High School
Honorable Mention:	Carmen N. Lee	Newsome Park Middle School
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Second Place:	Karen E. Hiza	Gloucester High School
First Place:	Jessica S. Kellogg	Gloucester High School

SPECIAL AWARDS

Major W. Catesby Jones Award for the STS winner displaying the greatest science potential.

2nd Runner-up: ($20)	Erin Lynch - Washington-Lee High School
1st Runner-up: ($30)	Thomas Huff - Douglas Freeman High School
Winner - ($50)	Aditya Seth - Thomas Jefferson H. S. for Sci. and Tech.

Botany Section Award, given by the Botany Section of the VAS, to the best paper on a botanical subject.($50.00)

Meredith A. Meyer - Washington-Lee High School

VJAS Neuroscience Awards supported by the Auxiliary of the Virginia Neurological Society are given to four outstanding papers in the field of neuroscience.($50.00 each).

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Khoan T. Thai - Washington-Lee High School

Rodney C. Berry Chemistry Award for the paper that evidences the most significant contribution in the field of chemistry.($50.00)

Aditya N. Seth - Thomas Jefferson High School for Science and Technology

Russell J. Rowlett Award for the Best Research Paper of the Year.($50.00)

Alan P. Moore - Gloucester High School.

The Virginia Psychological Foundation Meritorious Research Awards recognize outstanding presentations of research in the various fields of psychology. Each award includes a prize of $100.00.

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Katherine R. Saul - Yorktown High School
Christopher B. Highley - Governor's School for Govern. & International Studies
Ellen M. Davis - Warwick High School

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Maryanne Kiley - Gloucester High School

Health Physics Award is given by the Virginia Chapter of the Health Physcis society for outstanding research on topics related to ionizing radiation. ($500.00)

Gregory W. Harmon - Fieldale-Collinsville High School

American Cancer Society Award - This award is to recognize outstanding science papers related to cancer research. A certificate to each and to 1st place - $500, 2nd place $300, 3rd place $125, and honorable mention $75. These awards are provided by the American Cancer Society (Virginia Division), Public Education Committee.

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Third Place:	Khoan T. Thai	Washington-Lee High School
Second Place:	John G. Foulke	Yorktown High School
First Place:	Gregory Harmon	Fieldale-Collinsville High S.

The Gamma Sigma Delta Award (Agriculture). Presented by the VPI & SU Chapter of the Honor Society of Agriculture. This award of $100 is presented in recognition of excellence in research dealing with application of new technologies and/or concepts in agriculture forestry, or veterinary medicine.

Brian M. Green - Yorktown High School

W. W. Berry Award. This awards is given by VA Power in honor of Mr. W. W. Berry who was a past Chairman of the Board of VA Power. This award of 10 shares of Virginia Power common stock will be presented to the best engineering paper.

Phillip B. Northam - Smithfield High School

The Joyce K. Peterson Award is presented for the outstanding paper by a middle school student. It is presented in honor of Mrs. Joyce K. Peterson who has been an outstanding teacher in the Arlington County Schools.

John P. Dulka - Williamsburg Middle School

Trip to AJAS - AAAS Meeting for two students and two alternates for presenting outstanding papers. The 1995 meeting will be held in Feb. in Atlanta.

Winner - Jessica S. Kellogg - Gloucester High School

Winner - Brian M. Green - Yorktown High School

Alternate - John R. Zedlewski - Williamsburg Middle School

Honorary Membership - AAAS given to two students.

Mather Carter - H.B. Woodlawn

Timothy Brown - Governor's School for Government and International Studies

Honorary Membership - VAS given to one student.

Timothy Brown - Governor's School for Government and International Studies

E.C.L. Miller Club Award to the VJAS club having the most outstanding program for the year.($50.00)

The $1,000 Bethel Scholarship Award comes from the interest earned from a $10,000 endowment contributed by the students of Bethel High School, Hampton, Va., over a two year period. Accompanying this scholarship is a rotating plaque to be displayed in the student's school for the next year. This award is based on both the students presentation and paper.

Phillip B. Northam - Smithfield High School

Frances and Sydney Lewis Environmental Scholarship: A $13,000 scholarship ($3,250 per year for four years) for the best effort by a student grades 9 to 12 in the field of environmental science. This scholarship is in the name of Frances and Sydney Lewis and is given by the Virginia Environmental Endowment

Amy Billings - Fieldale-Collinsville High School

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THE VIRGINIA JOURNAL OF SCIENCE

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Vol. 45 No. 3 FALL, 1994

TABLE OF CONTENTS PAGE

Virginia Journal of Science
Volume 45, Number 3
Fall 1994

Instructions for Building Two Live Traps for Small Mammals

Robert K. Rose, Department of Biological Sciences,
Old Dominion University, Norfolk, Virginia 23529-0266.

ABSTRACT

The two live traps described herein, tested in the field over a period of 10 years, are sturdy, long-lasting, and relatively inexpensive to build with readily available materials and simple tools.

The all-weather live traps described here are modifications of a type designed by Fitch (1950). The principle of the Fitch trap is that when the small mammal walks through a swinging treadle to reach the bait in the nest box, the gravity-operated door drops behind it. The nest box for the traps, made from a 12 ounce drink can, is held by a friction connection that is easily broken when the contents are emptied into a bucket or bag. The Fitch live trap is a multiple-capture trap in which second and subsequent animals can enter by pushing against and then sliding under the dropped metal door. These two live traps have been used extensively in field studies of small mammals in southeastern Virginia and elsewhere, where a range of species and sizes to 150 g has been taken in the trap made from hardware cloth. The smaller trap, with a trap body made from 2.54cm square acrylic tubing, excludes mammals heavier than 20-25 g, thereby permitting only the smallest members of the small mammal community to be studied.

THE HARDWARE CLOTH (MESH) TRAP

To build the mesh trap (Figure 1a), a 23.5cm by 23.5cm piece of galvanized hardware cloth (also called hail screen) is bent into a 5.5 by 5.5cm trap body that is 23.5cm long. Hardware cloth with three meshes to the inch is best suited to building these traps but this size often is difficult to obtain in hardware or supply stores. (One-half-inch hardware cloth is most commonly available but if used to make traps the meshes are too large to hold harvest mice and most shrews; one-quarter-inch mesh is difficult to bend and even more difficult to make into a secure trap body, but traps built with this material will hold the smallest mammals.) The square of hardware cloth is trimmed on three sides, but the long ends of the fourth side are retained to be bent to build a sturdy trap body.

To make the trap body, a 24 to 30cm length of wooden board 50-51 mm square is used to bend the piece of hardware cloth into a square tube. Place the board on the hardware cloth at the edge of a table, and with the untrimmed side pointing away, bend 1cm of hardware cloth up with your thumbs. Then roll the board away from your body and bend the hardware cloth at 90° to form one side of the tube; continue this rolling movement, squaring up the corners as you go, until the square tube of the trap body has been fashioned. After the last bend, place the untrimmed wires through the first-bent corner. Next, using a needle-nosed pliers, bend each wire end around an adjacent mesh wire to make a symmetrical and sturdy trap body.

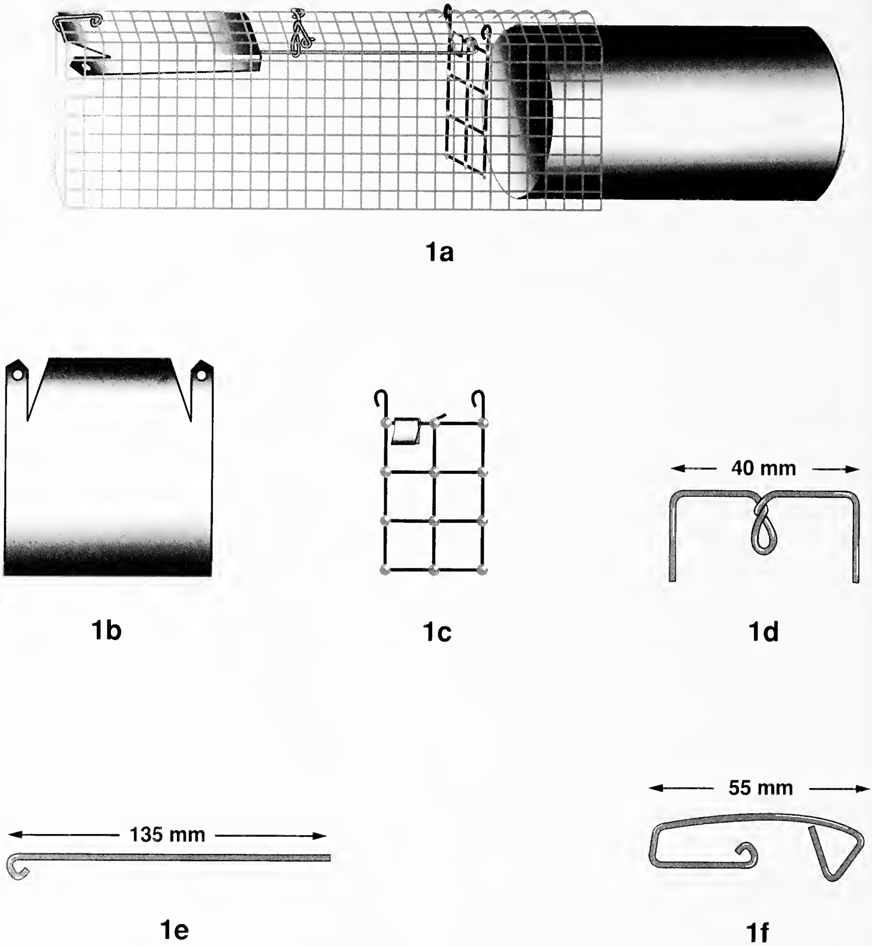

FIGURE 1. Model of completed Fitch trap made from galvanized mesh, together with patterns of the hand-made components.

If the hardware cloth is not square, some adjustments will have to be made to build a symmetrical and sturdy trap body.

Other components needed for construction are shown on Figure 1. The sheet metal door (Fig. 1b) is made from medium-weight (28-gauge) galvanized material that may be obtainable at low cost (as scrap) from a heating and air-conditioning or similar contractor. Each door is made from a 6.25-cm square, with small holes drilled in one side and then notched and rounded (Figure 1b), using a sheet-metal scissors. Then, using a board with a 6-mm deep saw cut, bend the two sides of the door to 90°. The door and hinge will work best if the top of the door is bent to 30° with fingers, a pliers or an angular cut in a board.

The swinging treadle is made from galvanized hardware cloth; the one shown in Figure 1c is made from two-meshes per inch galvanized mesh, but other mesh sizes will work too. The treadle (and indeed every part of the trap) is trimmed of sharp edges to minimize the possibility of the injury of captured animals. However the treadle is made, it should be symmetrical when hanging from the two wires, so that maximum sensitivity and sturdiness can be achieved. A small metal tab between the suspending wires minimizes the lateral movement of the trigger wire, thereby increasing the sensitivity of the trap too.

Parts 1d and 1e are made from 18-gauge galvanized wire. Especially for the trigger wire (1e), the wire must be pulled to straighten and strengthen it. To straighten wire, wrap one end around an eye-hook screwed into a post, run out 5 or 10 m of wire, cut and pull using a pliers, two hands, and your back. When pulled in this manner, the wire will stretch about 1-3 percent, and more importantly, the wire then becomes more ductile. For the size of Fitch trap described here, the hinge and trigger wires should be cut to 16cm lengths. The traps can be assembled most quickly if a supply of all components is available for use after several trap bodies have been made.

To assemble, place several trap bodies in a row, each with the seam on the table; there are fewer jagged edges for both small mammal and investigator if the seam is on the floor of the trap. Next, insert a door into the front of each trap. (Trap bodies and doors will vary slightly in dimensions, so matching the correct sizes at this stage saves time). Then, bend a hinge wire into an L-shape, with the short arm about 5.5cm long. While holding the door in the "up" position, insert the hinge wire inside and through the leading edge of one side of the trap body, through both holes of the metal door, and out the other side of the trap body. Next, using the needle-nosed pliers, bend the short arm of the hinge wire half-way down its length so that the bent end will pass into the trap body; then bend the leading end of the hinge wire up and insert it so that the wire can be crimped tightly and firmly around the trimmed hardware cloth at the front of the trap body. Bend the hinge wire down and repeat these steps on the other side to make the hinge complete. Afterwards, use pliers to raise or lower of one side of the hinge wire to make the bottom of the metal door level with the floor of the hardware-cloth trap body and to permit the door to drop freely and completely. When completed, each end of the hinge wire is wrapped firmly around the leading edge of the trap body.

Next, while holding the door in the "up" position, place a trigger-wire holder (Fig. 1d) about 2.5cm from the back (bottom) of the door. Using the pliers, bend the ends of the wires through and around the meshes of the hardware cloth so that this loop is well secured (see Fig. 1a). Next, hang the treadle about 4cm from the back end of the trap body so that it swings freely. Crimp the hooks to secure the treadle to the trap body. Then, to measure the exact length of the trigger wire (Fig. 1e), place its hooked end on the same transverse wire of the trap body from which the treadle is suspended. Raise the door into the "up" position while holding the end of the trigger wire with the same hand; cut the end of the trigger wire to the closest (back) edge of the trap's door. Next, use the pliers to hold the trigger wire by the loop end and insert it into the back of the trap body so that the trigger wire comes to rest next to the metal tab of the treadle while its end passes through the trigger-wire holder (Fig 1d), already in place. Crimp the loop of the trigger wire

to secure it next to the tab of the treadle; this is more easily done if the loop is above, and the trigger wire below, the transverse wire with the metal tab. (If you wish to allow the smaller mammals to come and go without being caught, use a shorter treadle, one that will not swing when the smallest animals walk under it.) The functional trap body is now complete.

An easy to use spring-clip can be fashioned and attached that will quickly and effectively lock open the trap during prebaiting or between trapping periods. This optional part (Figure 1f) is made from a 12cm piece of spring metal, bent into the appropriate shape and then crimped onto the third transverse wire from the front of the trap. (Adjustments are required here if hardware cloth of 2- or 4-meshes to the inch is used.) When properly made and installed, this clip will hold the door in the "up" position in prebaiting periods, permitting animals to freely enter and leave the trap without being caught. The best spring metal is stainless steel, but any non-corrosive springy metal about 18 or 19 gauge will work.

This Fitch trap uses a 12 ounce (355 ml) drink can as a nest box, but traps of different sizes can be built to accommodate larger or smaller cans. (The original Fitch [1950] trap used a 46 ounce [10.5cm diameter by 17.5cm long] tin can as the nest box, and the trap body was about 9cm by 9cm and 30cm long. Before bending, the hardware cloth is 30 X 37cm. Using a 10cm by 10cm square of sheet metal for the door and appropriately larger other components, this larger Fitch trap can be built using the directions given here.) The tops of drink cans cannot be easily removed because the deeply recessed lids cannot be cut with the standard can opener. The most effective and quickest way to open the top of a drink can is to use a sanding wheel; coarse grit cuts through the aluminum top in seconds, allowing the top to be pulled out easily. (Recently, a can opener has been marketed that might work safely; it cuts off the entire top, including the crimped lid). Once cleaned and filled with non-absorbent cotton or polyester fiber and bait, these cans become effective and long-lasting nest boxes.

To assemble the trap and nest box, use your fingers to bend and round up the back of the trap body and then slide it onto the open end of the can. A tightly fitting friction joint is crucial so that the trapped mammal cannot separate the trap body from the nest box by running back and forth. Steel drink cans, although rarer now, are sturdier than aluminum cans and will last for several years of continuous use in the field. These traps, when baited with wild birdseed (sometimes with extra sunflower seeds) have caught small mammals ranging from 6-8 g *Blarina carolinensis*, the southern short-tailed shrew, to 150 g *Sigmodon hispidus*, the hispid cotton rat. I have also caught one female *Mustela frenata*, long-tailed weasel, in the trap; earlier I caught a pair of long-tailed weasels in a larger Fitch trap (with 46 ounce can as nest box). This larger size also catches chipmunks, squirrels, and Norway rats (though the treadles and trigger wires often are damaged by these larger animals). These traps can be easily marked and anchored using surveyors' flags, with the 21" or 30" wires placed through the hardware mesh of one side of the trap body.

Two types of all-mesh live traps recently were reported to be superior to the standard all-metal Sherman live trap for capturing desert rodents (O'Farrell et al., 1994). The Fitch trap described above has a mesh trap body, where heat can be

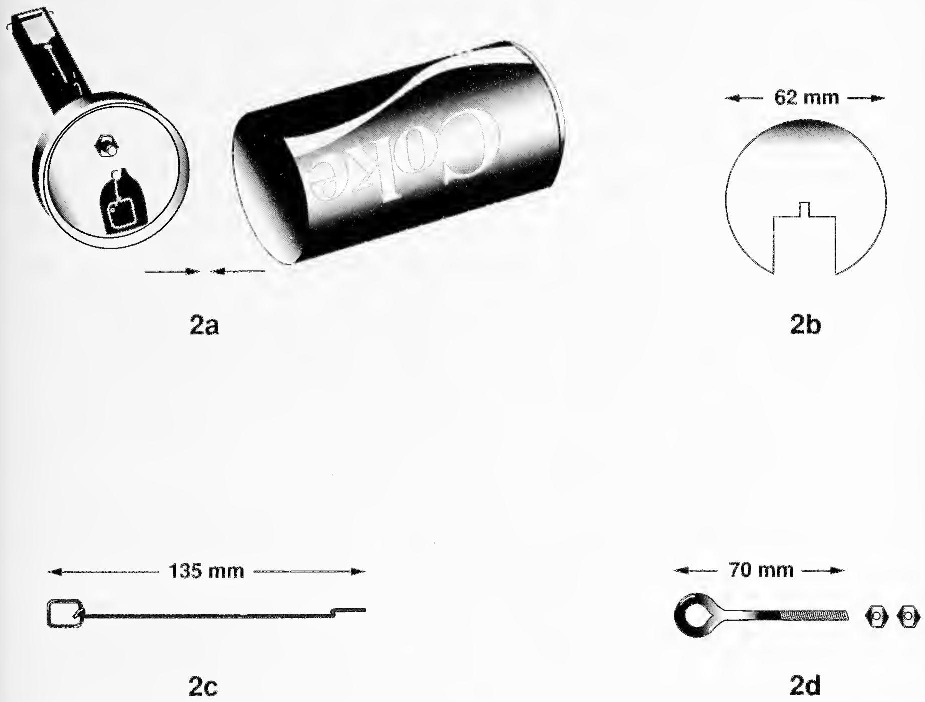

FIGURE 2. Model of completed trap mechanism and nest box of Fitch trap made from square acrylic tubing, together with pattern of the hand-made components (2b and 2c) and the purchased component (2d).

dumped, and a nest box, where the mammal can seek shelter to stay dry and conserve heat.

THE SMALLER TRAP MADE FROM SQUARE ACRYLIC TUBING

The raw materials to build this smaller trap are square acrylic tubing, 22 gauge wire, plexiglass, an eyebolt, and a drink can (Figure 2a). The trap body is made from 2.54cm clear tubing purchased in 10-foot sections at a plastics store and cut into 14cm lengths using a fine-toothed band saw. The door is hung on 22 gauge galvanized wire run through holes drilled near the top of the front of the trap. (A pair of similar holes, when drilled 1.5cm behind the holes for the hinge wire, can be used to hold a wire to lock the trap open during prebaiting or between periods of active trapping.) The door, 20mm wide and 30mm long, was made from a piece of discarded aluminum venetian blind, cut with an office paper cutter. One end of the rectangle of aluminum was rolled, using a sawed groove in a board and needle-nosed pliers, into a tube through which the hinge wire was inserted. The 3cm hinge wire then was bent at both ends to hold the hinge in place. Counting the thickness of the acrylic tubing and the head room for the door, the opening of this trap is about 17-18mm high and 21mm wide. This small size of opening effectively prevents mammals larger than 20-25 g from entering the traps.

The acrylic tubing is attached to the nest box by means of a plexiglas or lexan "shield," a 62mm disk with a U-shaped cut as shown in Figure 2b. A tight fit is needed so that the acrylic tubing can be strongly "welded" to the 6-8mm thick shield using Resin-Bond or similar solvent. The small notch in the shield is needed to accommodate the trigger wire, which in this trap lies outside and on top of the trap body. The trigger wire is made from galvanized 22 gauge wire, pulled and straightened as described above, and then bent as shown in Figure 2c. The.front end of the trigger wire is sent through a 5mm hole that has been drilled in the top of the trap body, about 42mm from the front of the trap. The trigger wire is the last component of the trap to be assembled (see beyond).

The nest box for this trap also is made from a 12 ounce aluminum drink can. Remove the tab from the can and then cut off the top 1.2-1.5cm, using a fine-toothed band saw. Then, place the plexiglass shield and attached trap body inside the top of the can so that the openings in the lid of the drink can and the back of the trap body are aligned. While holding these parts in alignment, drill a 6mm hole in the shield and lid about 1.5 to 2cm above the top of the acrylic trap body. A 7cm long by 4mm (2 3/4" by 3/16") eyebolt (Fig. 2d), with a nut on each side, is used to hold the shield and trap body to the top of the drink can. A rubber washer (which can be made from a piece of tire inner tube) should be placed between the lid and the plastic shield before using a wrench to make this connection secure. Then, use a good sheet-metal scissors to enlarge the opening in the lid of the aluminum can in order to match the opening with the inside dimensions of the acrylic tubing at the back of the trap body. After some cutting, the edges should be made flat and smooth with a file, again to reduce the possibilities of injury to the captured mammals.

Now install the treadle by running the wire (Figure 2c) through the notch in the shield and along the top of the acrylic body, and then inserting the tip through the 5mm hole in the top. Then, bend the squarish end part of that wire (Figure 2c) downward so that it becomes the treadle. As the mouse or shrew moves through this treadle, the wire moves and the door drops. Thus, the section of wire holding up the door must be trimmed to the appropriate length so that the door will drop when the treadle is moved as the mammal moves into the nest box for the bait.

Next, use the scissors to trim the rough edges from the remainder of the drink can. Then, using the eyebolt as a handle, the two parts of the trap are joined, as shown in Figure 2a. Because the two parts are so tightly held by friction, the eyebolt, and not the acrylic tubing, should be grasped to separate the trap body from the nest box when trapped animals are emptied into a bucket or bag.

When built of clear acrylic tubing, these traps proved to be ineffective in catching small mammals. However, when the clear acrylic tubing was made opaque by spray-painting it with black acrylic paint, an excellent trap resulted. (During a year-long study of oldfield small mammals in southeastern Virginia [Cawthorn and Rose, 1989], about 30 *Cryptotis parva*, least shrew, and a few hundred each of *Reithrodontomys humulis*, eastern harvest mouse, and *Mus musculus*, house mouse, were taken with these traps.) Before spray-painting with acrylic paint, a 3cm piece of masking tape was placed at the end of the trap; after painting, the tape was removed, enabling the investigator to see without stooping over and looking into the trap at near ground level whether the trap had been set off by a small mammal

entering it. In fact, one of the advantages of Fitch traps is that it is easy to see at a glance and often from a distance whether the trap door is in the up or dropped position.

In summary, the two traps described here can be built cheaply (the latter is more costly to build, and takes much more time to construct) with readily available materials and using simple tools. However, a band saw, drill press, and sanding wheel will speed production. Besides being inexpensive, these traps are sturdy, do not rust or corrode excessively, and remain in good working condition after years of continuous use. The trap made of hardware cloth (Figure 1) does not need cleaning, because the animals defecate in the wire part of the trap. This feature also makes it easy to collect fecal samples of individual animals simply by placing a piece of paper under the mesh part of the trap. The painted acrylic traps were left continuously in the field for a year, and eight years later after intermittent use they still have not become brittle. Thus, these traps also hold promise for a long period of usefulness.

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Is the Fall Line a Vegetational Boundary? Forest Succession in Pocahontas State Park, Virginia

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ABSTRACT

Forest vegetation studies in the Coastal Plain and Piedmont of Virginia have revealed that the dominant tree species are different in those two physiographic provinces. We asked whether this difference was caused by geological differences, or by other, perhaps climatic influences. In other words, is the physiographic boundary between the two provinces (the Fall Line) also the vegetational boundary? We sampled overstory, understory, sapling, and seedling layers of 30 old but second growth hardwood sites in the Piedmont 14 km west of the Fall Line. *Quercus alba* L. was the most abundant overstory tree, as is usual for both Piedmont and Coastal Plain. Typically Coastal Plain *Q. falcata* Michx. was important in more sites than typically Piedmont species like *Q. prinus* Willd., *Q. velutina* Lam., and *Q. coccinea* Muehchh., but *Q. rubra* L., sometimes regarded as Piedmont-related, was more important than *Q. falcata*. In the understory, sapling, and seedling layers, none of the oaks were important. *Cornus florida* L., *Acer rubrum* L., *Nyssa sylvatica* Marshall, and *Ilex opaca* Aiton were important in these lower layers; the first three are widespread in both physiographic provinces and the last is a typically Coastal Plain species. Among species likely to become overstory dominants in the area, only the typically Coastal Plain *Fagus grandifolia* Ehrh. was well represented in the three lower strata, with *Liquidambar styraciflua* L. a distant second. The absence or low importance of several Piedmont oak species in the overstory and the high importance of *F. grandifolia* and *I. opaca* in the lower strata means this Piedmont site is (or will be as succession proceeds) more like the Coastal Plain than like the rest of the Piedmont. Thus, the vegetational boundary is not at the physiographic boundary (the Fall Line), but is further west.

INTRODUCTION

Virginia's Coastal Plain and Piedmont physiographic provinces have both traditionally been treated as a part of an oak-(hickory)-pine forest region. Braun (1950) put forward this assumption for the areas north of the James River, and concluded that since pine was merely a successional species, oak and hickory would ultimately dominate in the climax communities of both these physiographic provinces. Braun (1950) believed that the Virginia Coastal Plain south of the James was part of a Southern Evergreen Forest Region, and she used the Fall Line as the boundary between that region and her Oak-Hickory-Pine Forest Region to the west. Oosting (1956) asserted that Braun (1950) actually had described not the climax vegetation of this region but its "fire, flood and edaphic 'subclimaxes'." He

thus concluded that neither the Fall Line nor the James River were vegetation boundaries, and that the entire Virginia Coastal Plain would develop oak-hickory climax vegetation. Küchler (1964) likewise included all the Virginia Coastal Plain in his oak-hickory-pine forest region along with the Piedmont, and this treatment was continued by Vankat (1979) and Greller (1988).

More recently DeWitt and Ware (1979), Clark and Ware (1980), and Monette and Ware (1983) all concluded that the maturing upland hardwood forest vegetation of the Coastal Plain and Piedmont of Virginia are different from one another. Both areas have much white oak (*Quercus alba* L.) but the Piedmont forests also have much scarlet (*Q. coccinea* Muenchh.), black (*Q. velutina* Lam.), and chestnut (*Q. prinus* L.) oak, while the Coastal Plain forests have relatively little of these and instead have much beech (*Fagus grandifolia* Ehrh.) and southern red oak (*Q. falcata* Michx.).

While none of these last three works said so explicitly, at least by implication they re-erected the physiographic boundary between the Piedmont and Coastal Plain (the Fall Line) as a vegetational boundary. However, Ware (1991) pointed out that Piedmont studies have been done mostly in the western half of the Piedmont (Gemborys 1974, Clark and Ware 1980, Farrell and Ware 1991), rather than the eastern part near the Fall Line, and that the vegetational boundary might not coincide with the Fall Line, but rather might be west of there, and that it might be a broad transition instead of a narrow zone like the Fall Line.

It is unknown whether the differences between the vegetation of these physiographic provinces in Virginia arise because of the geological and associated edaphic differences between the Coastal Plain and Piedmont provinces, or because of climatic differences between the western Piedmont and the more maritime-influenced Coastal Plain. The Swift Creek Natural Area of Pocahontas State Park in Chesterfield Co., VA, is 15 km west of the Fall Line, and geologically is clearly in the Piedmont, complete with the above-ground boulders and small rock exposures that characterize many Piedmont woods. However, it is geographically very close to the Coastal Plain and might be expected to be climatically much like the inner Coastal Plain. We undertook this quantitative study of vegetation and soil characteristics of the area to determine whether Coastal Plain-like or Piedmont-like vegetation is present in this area, as a step toward answering the question of whether physiography and geology are the deciding factors in determining the vegetational differences, or whether some other factors, perhaps climate, might play that role. We examined the overstory (large tree), understory (small tree), sapling and seedling layers to determine how the present composition of these old but second growth woods is changing (succeeding) in comparison to adjacent regions. We also examined how species distribution and abundance in all vegetation strata are affected by direction and degree of slope and by several edaphic factors.

METHODS

Sample sites were in the Swift Creek Natural Area in Pocahontas State Park, along the hiking trails that encircle Beaver Lake (an artificial impoundment on Swift Creek) and extend southward along Park Road (VA Rt. 780). Sites were chosen by walking along the trail and placing a sample plot upslope or downslope

from the trail each time there was a major change in the direction of slope (provided the site was sufficiently undisturbed). To be judged suitable for sampling, sites had to be dominated by large old hardwood trees and lack obvious signs of recent disturbance, such as saw-cut stumps, large canopy openings, or scorched bark (indicating recent ground fires). Areas dominated by tuliptree (*Liriodendron tulipifera* L.) were avoided, since it, like loblolly pine (*Pinus taeda* L.), is a successional species with broad ecological tolerances, and tends to obscure vegetational responses to environmental variables.

At each site a ten-meter radius circular plot was placed, and species and diameters of all trees at least 2.5 cm dbh (= diameter at breast height [1.37 m]) were recorded. Large trees were defined as woody stems ≥ 10 cm dbh, and small trees as stems ≥ 2.5 cm but < 10 cm dbh. For each species at each site in the large tree layer, percent of total basal area (= relative dominance) and percent of total density (= relative density) were calculated, and averaged to yield the relative importance value (I.V.) for a given species at that site. Species were considered important at a site if their I.V. ≥ 10. These same procedures were used for stems in the small tree layer. Woody stems having a dbh < 2.5 cm and that were at least 1.5 m tall were considered saplings; woody plants with heights ≥ 0.5 m and < 1.5 m were classified as seedlings. Saplings and seedlings were counted but not measured. For these strata, relative density (R.D.) was calculated for each species for each site. Species were considered important at a site if their R.D. was ≥ 10. Herbaceous species, which were very rare in these woods during our August to November sampling period, were not counted.

At the center of each plot we measured the direction of slope exposure (aspect) and degree of slope (an average of the degree of slope upslope and downslope). For correlation analysis, aspect in degrees was transformed by the cosine transformation of Beers, Dress, and Wensel (1966) (hereafter BDW aspect), with SW = lowest value and NE = highest value, and also by the asymmetric transformation of aspect of E. Crone and S. Ware (Crone 1991; hereafter C&W aspect). In the latter transformation, when aspect in degrees is 0 to 225 (N to SW), then $A' = \cos(A/1.25) + 1$, where A = aspect in degrees and A' = transformed value. When aspect is 225 - 360 (SW to N) then $A' = \cos[(A - 360)/0.75] + 1$. This transformation also assigns the lowest transformed value to SW, but the highest value in the C&W transformation is N, while it is NE in the BDW transformation. Both of these formulas were used because even though northeast slopes are considered the most favorable for total plant growth (Beers, et al. 1966), north-facing slopes are the coolest and moistest (Geiger 1965), which may affect distribution. At each sample site soil samples to 10 cm depth were extracted from three or four spots within the plot. Soil samples were sent to the VPI & SU soil laboratory for pH, Ca, Mg, P, K, Zn and Mn analysis. Soil texture analyses were performed using the LaMotte timed sedimentation method. As a rough approximation of soil organic matter, soils were grouped into six categories based on color, with the lightest colored soils given a value of one, and the darkest a value of six. Vegetation data were subjected to detrended correspondence analysis (DCA) ordination using CANOCO software (Ter Braak 1988). Tests for Pearson product-moment correlation of the various measured environmental variables with the ordination axes were used to detect vegetation-environment relationships.

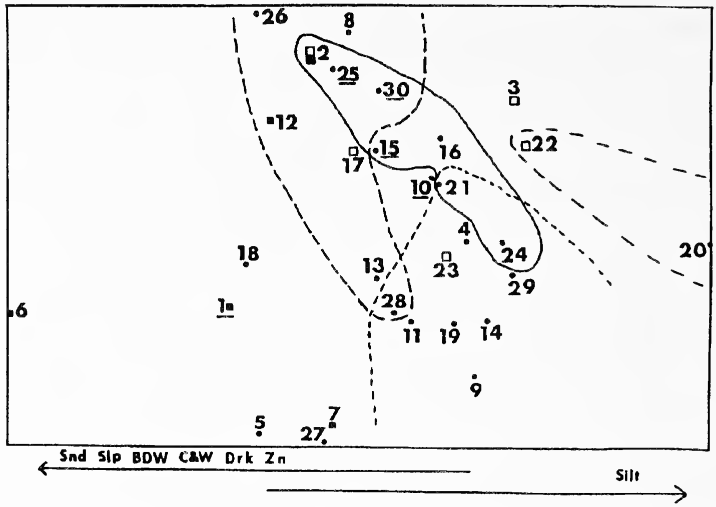

FIGURE 1a. A DCA ordination of the overstory layer of the 30 sampled sites. Arrows indicate direction of correlation of environmental variables with the axis. Snd = % sand; Silt = % silt; Slp = degree of slope; BDW = aspect transformed by the Beers et al. (1966) formula; C&W = aspect transformed by the asymmetrical formula of Crone and Ware (Crone 1991); Drk = darkness of A horizon (organic matter); Zn = soil zinc. The lower right short-dash line encloses sites with very high I.V. (≥ 50 %) of *Quercus alba*, which was important all across the ordination. The solid line encloses sites with *Q. falcata* I.V. ≥ 10; the upper center long-dash line encloses sites with *Q. rubra* I.V. ≥ 10; the right dashed line encloses sites with *Q. coccinea* I.V. ≥ 10. The five sites with underlined numbers had *Q. velutina* I.V. ≥ 10. The five sites represented by a solid square had *Fagus grandifolia* I.V. ≥ 10; the sites represented by an open square had *Liquidambar styraciflua* I.V. ≥ 10.

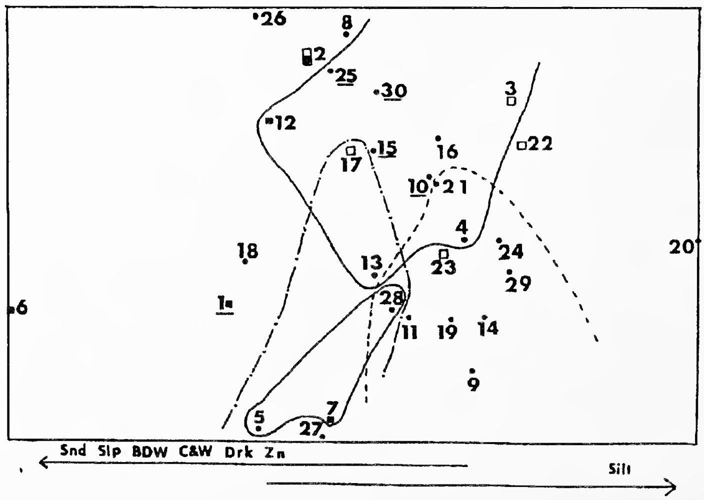

FIGURE 1b. DCA ordination as in Fig. 1a. The upper solid line encloses sites with *Liriodendron tulipifera* I.V. ≥ 10; the dash-dot line encloses all sites with *Carya glabra* I.V. ≥ 10; and the lower solid line encloses sites with *Acer rubrum* I.V. ≥ 10. The short-dash contour enclosure with *Q. alba* I.V. ≥ 50 is repeated from Fig. 1a for ease of comparison.

TABLE 1. Mean (standard error), median, and range of environmental variables for 30 sites.

Variable	Mean (S.E.)		Median	Range
C&W aspect	1.01	(0.69)	1.03	0 - 2.00
BDW aspect	1.06	(0.73)	1.26	0 - 2.00
Slope (°)	13.15	(7.73)	10.5	2 - 34
% Sand	58.00	(8.24)	57	40 - 80
% Silt	29.92	(7.05)	30	20 - 40
% Clay	13.30	(6.96)	13	3 - 37
Soil Color	3.34	(1.27)	3	1 - 7
pH	4.72	(0.33)	4.8	4.1 - 5.4
Minerals (ppm):				
Zn	1.47	(0.47)	1.4	0.9 - 2.5
Mn	14.47	(3.47)	16.1	3.6 - 16.1
P	2.57	(1.67)	2	1 - 9
Ca	178.11	(131.42)	144	60 - 624
Mg	33.73	(18.60)	30	14 - 107
K	50.57	(11.43)	51	29 - 82

The taxonomic nomenclature of Harvill et al. (1992) is followed. Most individuals of *Carya* spp. did not have mature fruit during the period of sampling. Since the vegetative characteristics are not always reliable in separating (*C. ovalis* (Wang.) Sarg.) from *C. glabra* (Miller) Sweet (Johnson and Ware 1982), sterile plants with one or more of the vegetative characteristics of *C. ovalis* were lumped with *C. glabra*. In the sapling and seedling layers no attempt was made to separate sterile *Vaccinium* and *Gaylussacia*. Previous experience of the second author with flowering or fruiting specimens in similar woods has shown that *V. stamineum* L. and *G. baccata* (Wang.) K. Koch (and in the Coastal Plain, *G. frondosa* (L.) T. and G.) are likely to be the predominant low ericads, and *V. corymbosum* L. the predominant tall species (sapling layer).

RESULTS

Large tree layer.

The DCA ordination for large trees is shown in Figs. 1a and 1b, and environmental variables are summarized in Table 1. Significant correlations ($P < 0.05$) of environmental variables with the axis of this and later ordinations are presented in Table 2 and shown on each ordination diagram. In the large tree ordination no environmental variables were significantly correlated with the second DCA axis. Site 6, heavily dominated by mockernut hickory (*Carya tomentosa* (Poir.) Nutt) and American ash (*Fraxinus americana* L.), and site 20, heavily dominated by scarlet oak, were isolated at either end of the first axis. A second ordination omitting these two sites did not yield an improved ordination; that is, it did not spread the sites out any more broadly across the ordination, and even fewer environmental factors were correlated with the axes, so only the original ordination is presented here.

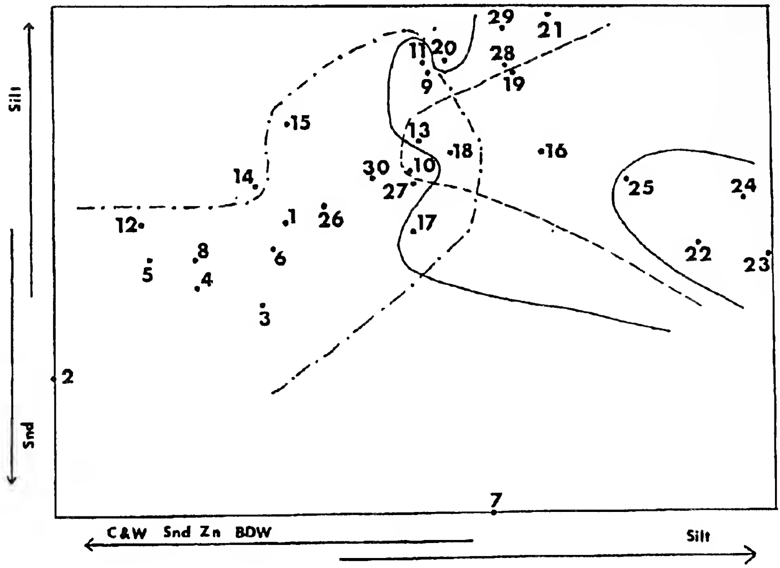

FIGURE 2a. DCA ordination as in Fig. 1a, but of the small tree layer. Sites with *Cornus florida* I.V. > 10 were spread broadly across the ordination. The upper center solid line encloses to the right sites with *Nyssa sylvatica* I.V. ≥ 10; the right solid line encloses sites with either *Carya glabra* or *C. tomentosa* I.V. ≥ 10; the dashed line encloses sites with *Liquidambar styraciflua* I.V. ≥ 10; the dash-dot line encloses sites with *Fagus grandifolia* I.V. ≥ 10.

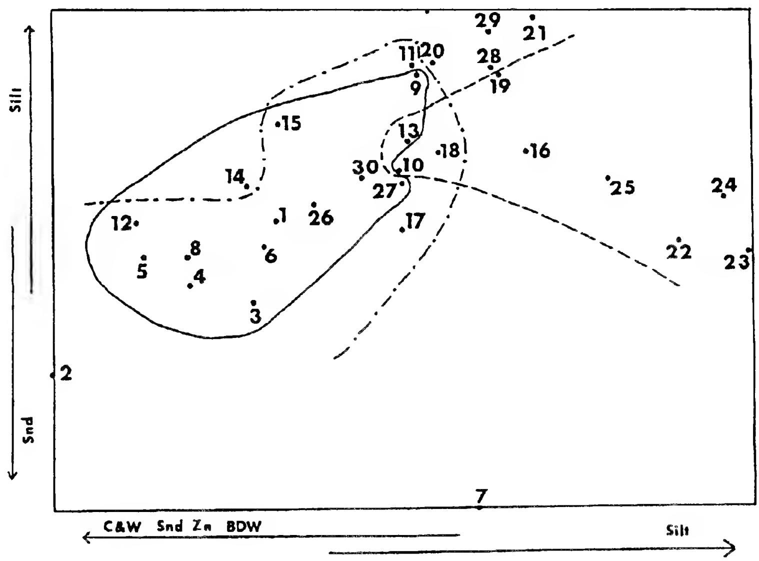

FIGURE 2b. DCA ordination as in Fig. 2a. The left solid line encloses sites with *Acer rubrum* I.V. ≥ 10; the right dashed line and the left dash-dot line repeat the enclosure contours for *Liquidambar styraciflua* and *Fagus grandifolia* from Fig. 2a for ease of comparison.

White oak was overwhelmingly the most important species in the overstory, with an I.V. ≥ 10 at all but two (#5 and #17) of the 30 sites, and I.V. > 25 at 21 sites. Sites in which white oak had the highest I.V.'s (≥ 50) were concentrated in the lower right center portion of the ordination (Fig 1a).

Though tuliptree-dominated sites were not sampled, this widespread species was nonetheless a component at many sample sites dominated by other species, reaching I.V. ≥ 10 at eleven sites. It was most abundant in the upper center portion of the ordination (Fig 1b), often at the same sites where southern red oak and black oak were important (Fig. 1a), and overlapping the area of high importance of northern red oak (*Q. rubra* L.). In contrast with tuliptree, sites with high pignut hickory (*Carya glabra*) I.V. were concentrated at the lower end of the second ordination axis (Fig. 1b), as were the three sites with red maple (*Acer rubrum* L.) I.V. ≥ 10. Though there was a concentration of the red and black oaks and tuliptree at the upper end of the second ordination axis (Fig. 1a), and a concentration of pignut hickory, red maple, and highest I.V. of white oak at the lower end, none of the measured environmental variables were correlated with the second axis. The five sites with mockernut hickory I.V. ≥ 10 were scattered widely over the ordination.

Beech had an I.V. ≥ 10 in the overstory in only five of the 30 sites, with all five on the left half of the first axis of the ordination, with higher aspect values, higher sand, and darker soil (higher soil organic matter). Black oak, typically a Piedmont species, was important largely within the enclosure contour of southern red oak, a typically Coastal Plain species (Ware 1991), and the other typically Piedmont species, scarlet oak, reached I.V. ≥ 10 only at two sites. Other species that had I.V. ≥ 10 at least two sites in the overstory were sweetgum (*Liquidambar styraciflua* L.), 5 sites; and blackgum (*Nyssa sylvatica* Marshall), loblolly pine, and post oak (*Quercus stellata* Wang.), each with two sites. Chestnut oak was not encountered at all in this study.

Small tree layer.

The ordination of the small tree layer is presented in Figs. 2a and 2b. Site #7 (strongly dominated by *Carpinus caroliniana* Walt.) is isolated because though *C. caroliniana* occurred at 13 sites, it was usually of low I.V., reaching an I.V. ≥ 10 at only two other sites. Omission of site #7 did not yield an improved ordination, however. Flowering dogwood (*Cornus florida* L.), beech, red maple, black gum, holly (*Ilex opaca* Ait.), and sweet gum were important species in the small tree layer. Dogwood, an understory tree, was the most important species in this layer, with an I.V. ≥ 10 at 24 of the 30 sites. Its lowest I.V.'s were in the 5 left-most sites. Beech was the most important potential overstory species in the small tree layer. It reached I.V. ≥ 10 at 19 sites, 15 of which did not have high beech I.V. in the large tree layer. High red maple I.V. was strongly associated with high beech I.V. (Fig. 2b), while high I.V. of both blackgum and sweetgum were concentrated at the opposite end of the first axis of the ordination, where aspects were lower and soil was finer-textured. Four of the five sites with *Carya* spp. I.V. ≥ 10 were also found there. The 12 sites with high I.V. of holly were spread across the upper center of the ordination, overlapping broadly the concentration of high beech-high red

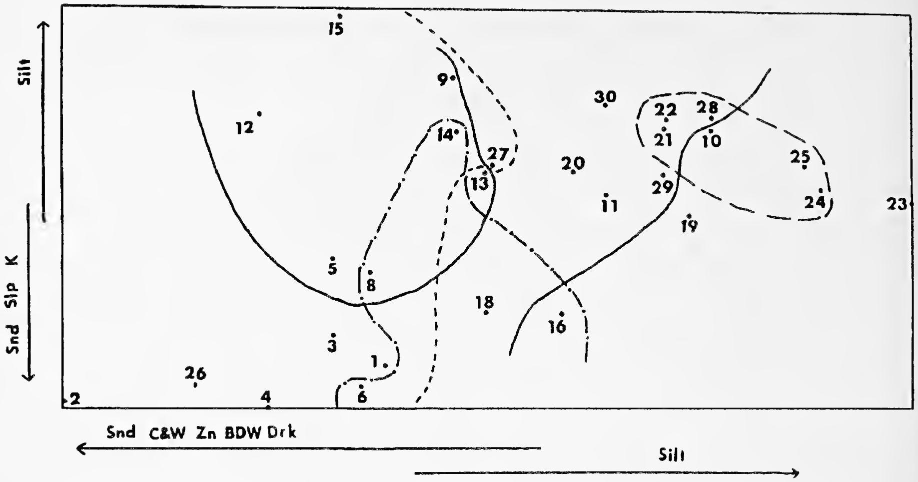

FIGURE 3. DCA ordination as in Fig. 1a, but of the sapling layer. K = soil potassium. High relative density (R.D.) of *Cornus florida* and *Ilex opaca* are spread broadly across the ordination. The short-dash line in the center encloses to the left sites with *Fagus grandifolia* R.D. ≥ 10. The upper left solid line encloses sites with high (>25) *Acer rubrum* R.D.; the lower center dot-dash line encloses sites with *Carpinus caroliniana* R.D. ≥ 10; the right solid line encloses to the right sites with *Liquidambar styraciflua* R.D. ≥ 9; the right long-dash line encloses sites with high (>25) R.D. of *Nyssa sylvitica*.

maple and high black gum-high sweet gum sites. However, holly was absent from the six left-most and the three right-most sites.

Despite their importance in the overstory, northern red, southern red, black, and scarlet oaks and tuliptree failed to reach I.V. ≥ 10 in the small tree layer, and white oak did so in only one site.

Sapling layer.

An ordination of this layer is presented in Fig. 3. In the original ordination of the sapling layer, site 7 (heavily dominated by *Corylus americana* Walt., which occurred nowhere else) and site 17 (heavily dominated by *Asimina triloba* (L) Dunal) were isolated at the ends of the first and second DCA axes, respectively. Omission of those two anomalous sites from a second ordination produced a better spread of sites and significant correlation of several environmental variables with the first and second DCA axes, so the ordination presented here has the two anomalous sites omitted.

Dogwood was the most abundant species in the sapling layer, with relative density (R.D.) ≥ 10% in 24 of the 30 sites, and R.D. ≥ 25% in 15 of these sites. Three sites with no dogwood (#2, #4, #12) are on the far left of the first DCA axis. Red maple was the second most important species, with R.D. ≥10 at 17 sites all across the ordination, but the 7 sites with R.D. >25 were concentrated in the upper left portion of the ordination (Fig. 3). The nine sites with holly R.D.≥ 10 were spread broadly across the ordination, co-occuring with high R.D. of every other important species in one or more sites, while sites with high *Carpinus caroliniana* were concentrated in the lower center portion of the ordination. Beech was the most important potential overstory species in the sapling layer, reaching R.D. ≥10

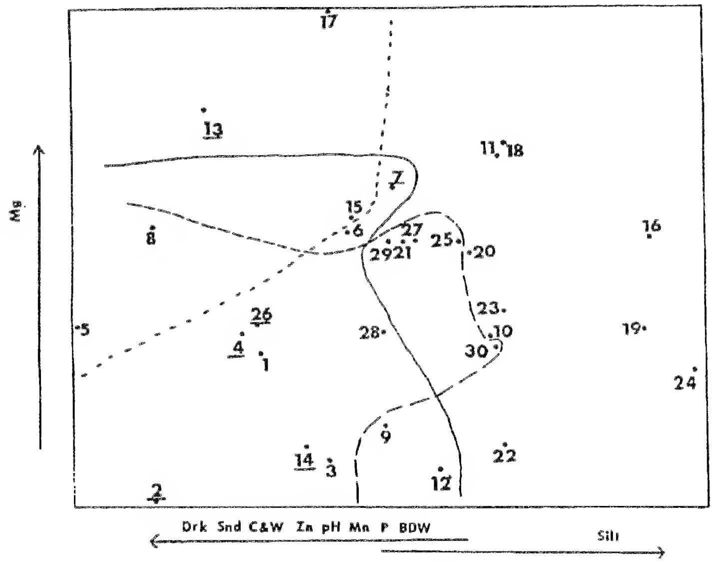

FIGURE 4a. DCA ordination as in Fig. 1a, but of the seedling layer. Additional environmental variables not given in Fig. 1a are Mg, Mn, P, and pH, referring to soil minerals and acidity. The solid line encloses sites with *Fagus grandifolia* relative density (R.D.) ≥ 10; the long-dash line encloses sites with *Ilex opaca* R.D. ≥ 10; the short-dash line encloses sites with *Asimina triloba* R.D. ≥ 10. The six sites with their numbers underlined have *Fraxinus americana* R.D. ≥ 10.

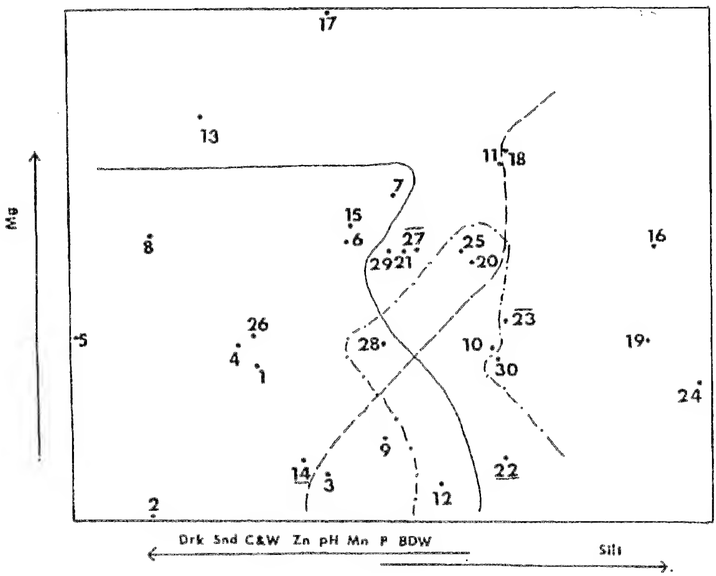

FIGURE 4b. DCA ordination as in Fig. 4a. The dashed line encloses to the right sites with *Liquidambar styraciflua* R.D. ≥ 10; the dot-dash line encloses sites with *Vaccinium/Gaylussacia* spp. R.D. ≥ 10; the solid line repeats the *Fagus grandifolia* contour from Fig. 4a for ease of comparison. The two sites with bars over the numbers had *Carya glabra* R.D. > 10; the two sites with bars under the numbers had *Carya tomentosa* R.D. > 10.

in 14 sites. It was important in the left side of the ordination, in the same sites where it was important in the small tree layer. Though blackgum and sweetgum were most important in sites on the right side of the ordination where soils are silty and slope is less steep and of lower aspect, both species also reached R.D. ≥10 in some sites on the left side of the ordination. American ash reached R.D. ≥10 in two sites and was present in seven other sites, all on the left half of the ordination. Of other species important in the large tree (overstory) layer, northern red oak, mockernut hickory, pignut hickory and tuliptree reached R.D. ≥10 in only one site each in the sapling layer.

Seedling layer.

The ordination of the seedling layer is presented in Figs. 4a and 4b. More measured variables were significantly associated with this ordination than with any of the other layers. Dogwood was abundant as a seedling all across the ordination, reaching I.V. ≥ 10 at 21 sites. The areas of high concentration of holly, beech, white ash, and *Asimina triloba* (Fig. 4a) were on the left half of the first axis. Sweetgum was concentrated on the right and lower center portion of the ordination (Fig. 4b), and *Vaccinium/Gaylussacia* spp. were concentrated in the lower right center of the ordination. Red maple reached R.D. ≥ 10 in only two sites. Other species with R.D. ≥ 10 in at least two sites were *Carpinus caroliniana* (four widely scattered sites), pignut hickory, mockernut hickory, white oak, and *Diospyros virginiana* L. (persimmon).

DISCUSSION

Though white oak was the overwhelming dominant in the overstory, it was not reproducing itself, for it was important at only one site of the small tree layer and at only two sites of the seedling layer; the species did not reach R.D ≥ 10 in the sapling layer. Our study area was like the Coastal Plain study area of Monette and Ware (1983), in that white oak was not reproducing well at those sites where it was a overstory dominant. In our study as in Monette and Ware's (1983), white oak is apparently successional, for it is not reproducing, while beech, sweetgum, blackgum and red maple are important in the lower strata at those sites where white oak is a overstory dominant.

Northern red oak was another important component of the overstory in some sites (Fig. 1a). It often was important at the same sites as tuliptree, unlike Kasmer et al.'s (1984) finding that the two strongly dissociated from one another in the Pennsylvania Piedmont. However, northern red oak was not reproducing, since it was rarely present in the lower layers of vegetation; the same holds true for tuliptree, southern red oak, black oak and scarlet oak.

Pignut hickory and mockernut hickory had an I.V. ≥ 10 in the overstory at six and four sites respectively, and though they were better represented in lower layers than oak, the sites where they were most abundant in the lower layers were not necessarily the same ones where they were important in the overstory. Therefore, like the oaks, the hickories appear to be reproducing poorly under shade.

In contrast to the species above, beech and sweetgum were well represented in the reproductive layers. While exceeding I.V. of 10 at only 5 sites in the overstory, beech reached an I.V. of 10 in an additional 14 sites in the small tree layer, and R.D.

≥ 10 in an additional 3 sites in the remaining two layers. In all layers we found the most beech on northerly and easterly facing slopes, which are generally moister than other exposures (Geiger 1965). However, beech also had higher importance in sandy soil, which is regarded to be drier than silty soil (Marks and Harcombe 1981). The greater abundance of beech on northerly and easterly slopes vs. its lower importance on southerly and westerly slopes might be interpreted as the result of a moisture gradient. However, the gradient of higher beech importance at sandier sites and lower importance at less sandy sites would suggest an opposing moisture gradient, and thus would at least partially nullify a solely moisture-based interpretation. The effects of direction of exposure and of sandiness may cancel each other; further studies should be carried out to determine how these two variables interact and the degree to which each affects soil moisture individually. In any case, unless there is a severe disturbance in the understory, beech will surely be the species of highest importance in the future overstory at a large majority of our sites, given its abundance in the small tree, sapling, and seedling layers.

Sweetgum reached I.V. ≥ 10 in the overstory in only five sites, reached that level in six additional sites in the small tree layer, and R.D. ≥ 10 in an additional four sites in the remaining two layers. Only one of the sites where the species was important in the overstory lacked high sweetgum importance in one or more of the lower layers. Thus, while sweetgum does seem to be recruiting into the lower strata, it is less likely to be present in all three of the lower layers than is beech, and sweetgum's greatest importance is reached in lower aspect, high silt sites where beech isn't very important. Given that the presence of sweetgum in lower layers in upland sites doesn't always presage its ultimate entry into the overstory (Oosting 1942; Monette and Ware 1983), it is hard to predict whether sweetgum will actually increase or decrease in importance as succession proceeds.

Unlike most of the overstory species, the important species of the small tree layer were represented in the sapling and/or seedling layers. Dogwood was abundant all across the small tree, sapling, and seedling layer ordinations. Its highest dominance in the small tree layer was associated with silty soils, though this may be an artifact of the reduced abundance of beech and red maple in these soils (Fig. 2b), since dogwood was abundant without respect to edaphic factors in the sapling and seedling layers.

Holly, an important understory species, reached highest importance at the high silt end of the ordination in the small tree layer, but in the sapling and seedling layers the species reached highest importance at the high sand end of the ordination. This anomaly may possibly be explained by the sandier sites being older forest (further along in succession) with the holly having already gotten large enough to count in the small tree layer, but not reproducing well under heavy shade. Siltier sites may be younger forests, with holly still in the younger age classes, but not yet large enough to count in the small tree layer. In contrast, blackgum may not have this broad tolerance of soil texture that holly does, since blackgum was associated with silty soil in both small tree and sapling layers (the only two strata where blackgum was important; it did not reach R.D. ≥ 10 in the seedling layer).

Red maple was important in only three sites in the overstory (Fig. 1b), but it was one of the most abundant species in the small tree and sapling layers, important at 14 and 17 sites, respectively. In the small tree layer red maple was strongly

TABLE 2. Significant correlations ($P < 0.05$) between DCA vegetational axes and environmental variables. See text for explanation of the two aspect variables.

Size stratum:	Large Trees		Small Trees		Saplings		Seedlings	
DCA Axis:	I	II	I	II	I	II	I	II
Eigen value:	0.44	0.28	0.44	0.17	0.50	0.27	0.42	0.28
Environmental variables:								
C&W aspect	-0.393	ns	-0.509*	ns	-0.449	ns	-0.547*	ns
BDW aspect	-0.444	ns	-0.375	ns	ns	ns	-0.387	ns
Slope (°)	-0.468*	ns	ns	ns	ns	ns	ns	0.417
% Sand	-0.471*	ns	-0.502*	-0.420	-0.501*	-0.447	-0.547*	ns
% Silt	0.376	ns	0.379	ns	0.417	0.431	0.521*	ns
Soil Color	-0.428	ns	ns	ns	ns	ns	0.554*	ns
Zn	-0.408	ns	-0.400	ns	ns	-0.381	-0.524*	ns
Mn	ns	ns	ns	ns	ns	ns	-0.469*	ns
P	ns	ns	ns	ns	ns	ns	-0.431	ns
pH	ns	ns	ns	ns	ns	ns	-0.495*	ns

*$P < 0.01$. Clay (%), Ca, Mg, and K were not significantly correlated with any axis.

associated with beech in sandier soils on northerly and easterly aspects. In the sapling layer this association broke down, and red maple occurred much more broadly, with no association with any measured environmental variable. This may, as with holly, suggest a successional differential, with red maple not yet large enough to be important in the small tree layer at younger sites. Despite its importance in the small tree and sapling layers, red maple, like blackgum, was poorly represented in the seedling layer of all but two sites.

The present overstory, then, is in a state of succession. Neither oaks nor tuliptree are reproducing. Farrell and Ware (1991) also found that the important species in the overstory of their Piedmont sites were not reproducing, except for hickory, but in our study area not even hickory was reproducing well. American beech, red maple, sweetgum, blackgum, and white ash are the important species of the lower strata with the theoretical potential to enter the overstory. However, it was noted above that sweetgum may not successfully enter the canopy layer, and it is also the case that in both the Piedmont and Coastal Plain red maple and blackgum usually remain understory species in upland sites (Christensen 1977, Clark and Ware 1980, Monette and Ware 1983, Ware 1991). It is also uncertain that white ash, important in the seedling layer of some sites, will successfully reach the overstory in a closed canopy forest. Beech will probably come to dominate the overstory in the future, and if it continues to reproduce as at present, beech will remain a dominant in all strata until a disturbance occurs.

The environmental factors that show correlation in the distribution and importance of the various species within the various strata have been discussed above with each of the respective species. Overall, soil texture was the environmental factor that was correlated most often with the patterns of distribution (Table 2).

Sand and silt were significant factors in all four vegetation layers. Aspect was also a significantly correlated variable (C&W aspect all four strata; BDW aspect in two strata).

Other significant environmental factors that were correlated in at least two of the layers in this area were degree of slope, soil color (organic matter), and Zn. Zn is an unusual mineral to be correlated with vegetational distribution and abundance, in that few studies have found such an association.

The seedling layer was most strongly associated with the measured environmental factors, since ten factors were significantly correlated with the first and second axes of the seedling ordination (Table 2). Mn and P were significant only in the seedling layer. Fewer significant correlations between environmental factors and ordination axes were found the other layers: seven in the overstory, five in the small trees, and four in the saplings.

It might be argued in theory that the overstory layer of older second growth forests might be expected to show the greatest effect of past disturbance, and thus the least correlation with measured environmental variables, while the seedling layer of these forests, especially older ones, should show the least effect of disturbance, and thus the greatest correlation with environmental variables. However, in our study area the overstory showed significant correlations with more environmental variables than the intermediate layers. As mentioned earlier, dogwood, holly, red maple, and blackgum remain in lower strata long after their initial invasion, so the initial establishment of individuals of these species at a site may have taken place nearly the same time as the establishment of other species that are now in the overstory. The distribution of the understory species among sites in the small tree and sapling layers thus may be as likely as that of the overstory trees to reflect past disturbance. Given that understory species often are abundant at a much larger proportion of sites than potential canopy species, these understory species may also have broader environmental tolerances than the species of the overstory. Thus, correlation with measured environmental variables will not necessarily be higher in the small tree and sapling layers than in the overstory layer.

Ware (1991) described the Coastal Plain's maturing vegetation to be dominated by white oak, beech, and southern red oak, whereas white oak, chestnut oak, scarlet oak and black oak characterize the Piedmont. Some (Gemborys 1974, Farrell and Ware 1991) have reported northern red oak to be important in parts of the Piedmont, and it might be argued that it is also a Piedmont species. Though the characteristically Piedmont chestnut oak is absent, 50% of the sites (15 of 30) had northern red oak, black oak, or scarlet oak as important species, and beech was important at only five sites, so the present overstory seems to have more Piedmont-like vegetation. In contrast, beech is important at many sites of the understory, and holly is also important in the small tree and other layers. Neither beech nor holly are very important in the understory of typical Piedmont forests (Ware 1991).

The abundance of these typically Coastal Plain species in the lower layers supports the notion that the Swift Creek Natural Area of Pocahontas State Park contains (or will ultimately contain) Coastal Plain-like vegetation. The finding of Coastal Plain type vegetation west of the Fall Line refutes any assumption that the Fall Line *per se* is the vegetation boundary between Coastal Plain and Piedmont vegetation. This is concordant with the findings of Binns (1980), who, looking only

at the herb and shrub layers of the forest, found no sharp change in vegetation along a 116 km transect in Virginia that crossed the Fall Line.

As noted earlier, Ware (1991) suggested that the vegetational boundary between the Coastal Plain and Piedmont need not be coincident with the physiographic boundary, and suggested that the vegetational boundary might be a transitional zone west of the Fall Line. Although the physiographic characteristics west of the Fall Line are different from these of the Coastal Plain, it seems that these geologic and edaphic factors are not sufficient to cause a great change in the mature vegetation just west of the Fall Line. Further studies need to be done farther west in the Piedmont to determine the nature and location of the boundary or transitional zone between the Piedmont-like and Coastal Plain-like vegetation provinces of Virginia.

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Spectral Characterization of Acid-Mine and Neutral-Drainage Bacterial Precipitates and Their Relationship to Water Quality in a Piedmont Watershed

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ABSTRACT

Mining residues have an enormous impact on water quality; however, not all associated red, orange, and yellow drainage precipitates indicate acid conditions. Recently, preliminary work in a Virginia Piedmont stream affected by mine drainage demonstrated that a passive spectral technique may exist to differentiate between acid and neutral drainages. *In-situ* spectral reflectance measurements (350 to 900 nm) were collected on bacterial precipitates in Contrary Creek, near Mineral, Virginia. Spectra also were collected on bacterial precipitates in a neutral tributary stream. Each drainage had associated with it different water quality and bacterial communities. For each of the stream precipitates evaluated in this study, different spectral reflectances were recorded which were strongly associated with specific conductivity levels. Spatial and temporal changes did not influence the reflectance values as the acid precipitate reflectances were an average 44% brighter than the neutral precipitates.

Key words: spectral reflectance, acid mine drainage, bacterial precipitates, water quality

INTRODUCTION

Acid drainage from active and abandoned mines is a major water-quality concern (Bureau of Mines, 1994). Where iron is present, the impact is highly visual -- precipitates of yellow, orange, and red colors line the creeks and rivers (Lackey, 1938). The Virginia Piedmont is characterized by iron-bearing rocks weathering under a humid, temperate regime. Coal and metals actively have been mined there since European settlement (Wilkes, 1988). The mineral pyrite, which occurs in the coal and as veins in crystalline rocks, is the major source of acidity (Poole, 1973).

The bacteria that participate in the production of iron precipitates or flocculates in acid waters usually are classified under the name of the most easily cultured member of a complex consortium, *Thiobacillus* (Ehrlich, 1990). The acidophilic thiobacilli are autotrophs, which means that this species actually derives energy from oxidizing the iron or the sulfur in pyrite (Singer and Stumm, 1970). This oxidation results in the production of sulfuric acid and precipitates that appear orange to yellow in the visible spectrum. These precipitates are commonly called "yellow boy."

In contrast, neutral waters that bear iron contain a different group of bacteria. The so-called "iron depositing bacteria" predominate where anoxic ground water

transports ferrous iron (Fe^{2+}) and discharges it into oxygen-rich surface waters (Pringsheim, 1949). Their precipitates appear more red to red-orange in the visible spectrum. This consortium includes facultative anaerobes, microaerophiles, and aerobes that proliferate at the redox boundary (Ehrlich, 1990). Some, such as Gallionella, actually get energy from the oxidation of iron; such autotrophy has not been proven for the other members of the iron bacteria consortium. For these bacteria, iron oxidation may be a byproduct reaction (Ehrlich, 1990). Where the dried precipitates of these iron bacteria have been studied, ferrihydrite is the resulting iron-oxide mineral phase (Chukrovet al., 1973; Ferris et al., 1989). One of the consortium, *Leptothrix discophora*, forms oily films that spread out across the surface of the water (Ghiorse, 1984) and become redder through time. It is suggested that the color change is the result of dehydration reactions as ferrihydrite mineralizes to hematite (Robbins, 1994).

Yellow and red flocculates are colorful but look menacing (Chapelle, 1993). The menace is real where acids and soluble metals of acid drainage kill aquatic life and river bank vegetation. All such colors in waters are considered to be a problem to those untrained in the differences between the acid and neutral iron-oxidizing bacteria.

This investigation seeks to demonstrate that the precipitates of acid-mine and neutral bacteria have different spectral reflectance properties that can be associated with different water qualities. Similar approaches have been used to evaluate water quality using chlorophyll spectra from algal biomass and suspended sediments (Dierberg and Carriker, 1994). The end product of such a technique has translated into remote-sensing strategies for water-quality monitoring. Historically, applying remote sensing to evaluating mine wastes has been attempted since the ERTS 1 generation of sensors (Alexander et. al., 1973). Additionally, correlations between spectral data and water-quality data have only recently been investigated with studies involving the evaluation of various sensors for water-quality monitoring (Carboni and Moreau, 1990).

METHODS

For this investigation, a creek was chosen having neutral ground-water seeps and acid-producing mine runoff in the same watershed. Contrary Creek (Figure 1) near Mineral, in Louisa County, Virginia, drains five pyrite deposits that were actively mined in the 1840s and 1850s (Poole, 1973). The host rock of the mineralization is the Chopawamsik chlorite biotite schist; individual pyrite veins are as thick as 200 meters. The study site is located north of Mineral, Virginia at the intersection of the US 522 bridge and Contrary Creek. The U.S. Geological Survey gaged the creek at the US 522 bridge from 1989-1992 and measured pH values which ranged from 2.9 to 4.8 (B.J. Prugh, Jr., written commun., 1994). Dissolved sulfate was measured at 110 mg/L. In mg/L, total iron was 15, dissolved iron 11, dissolved Mn 0.87, and Zn 1.9. For this study, water-quality measurements including pH, specific conductivity, dissolved oxygen, and temperature were recorded monthly from March to October 1994 at the Contrary Creek site using hand-held instruments. These measurements were collected to assess temporal variations in water quality which may influence the spectral signatures of the precipitates (Figures 2-5). Coincident with water quality measurements, spectral

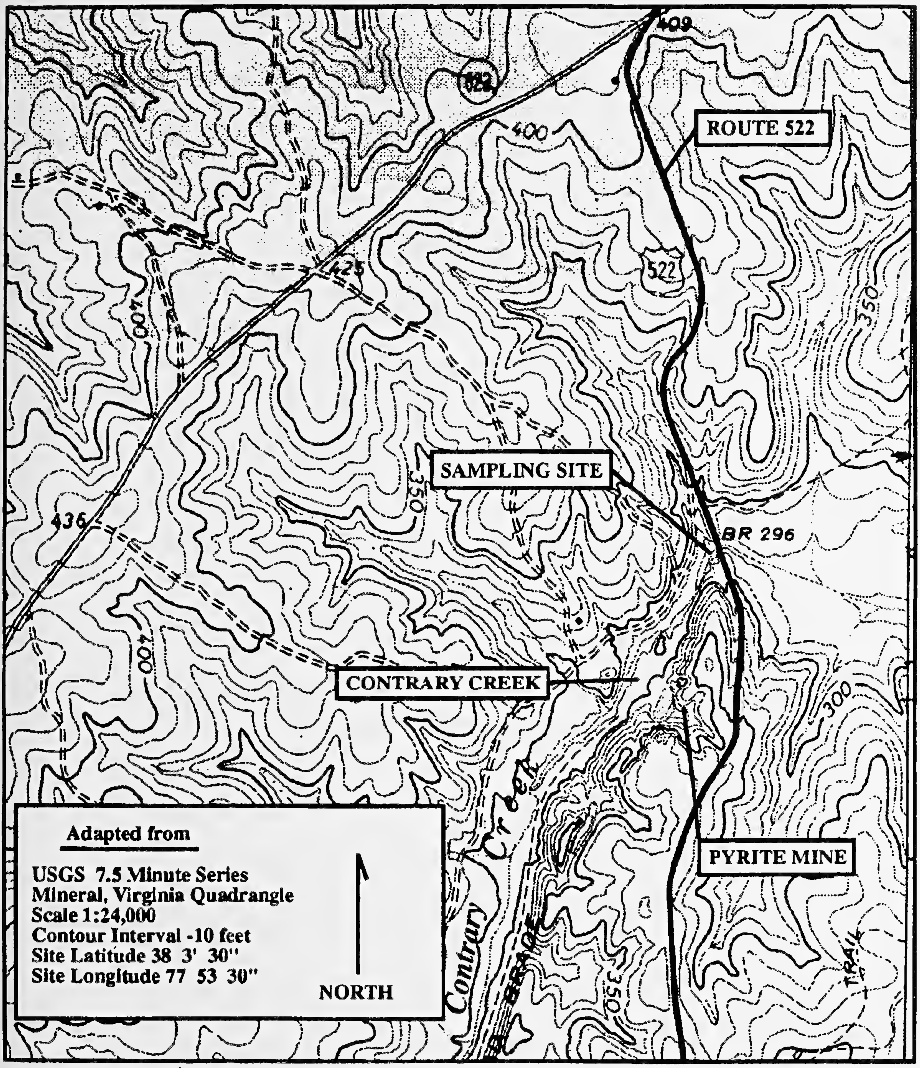

FIGURE 1. Location of sampling site along the Contrary Creek watershed near Mineral, Virginia.

reflectance measurements in the 350 to 900 nanometer bandpass (visible to near infrared) of acid-mine and circumneutral bacterial precipitates were collected monthly at the Contrary Creek site. This bandpass was selected because it covers the entire visible as well as a large part of the near-infrared portion of the electromagnetic spectrum. Spectral reflectance data are collected in-situ along a

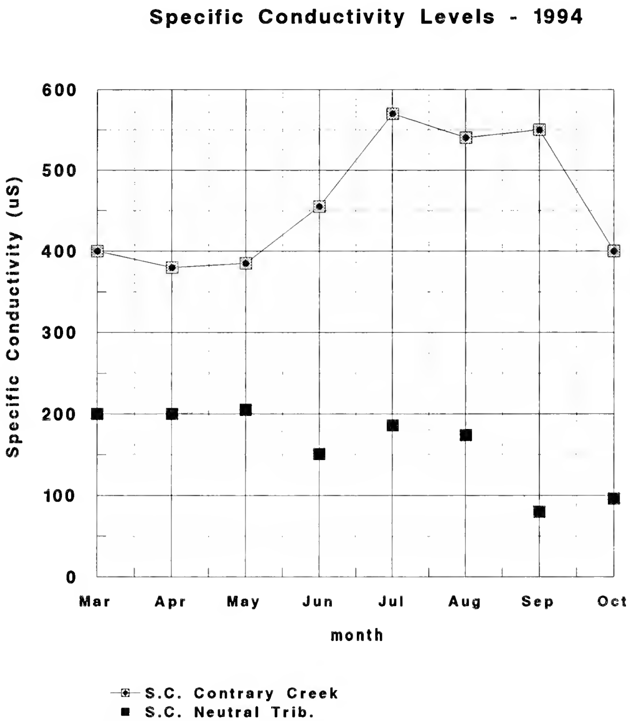

FIGURE 2. Specific conductivity levels at Contrary Creek and the neutral tributary.

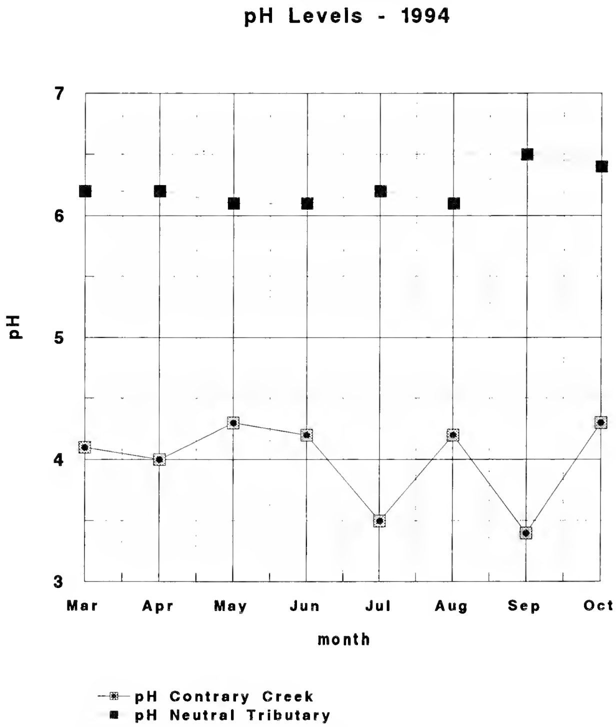

FIGURE 3. pH levels at Contrary Creek and the neutral tributary.

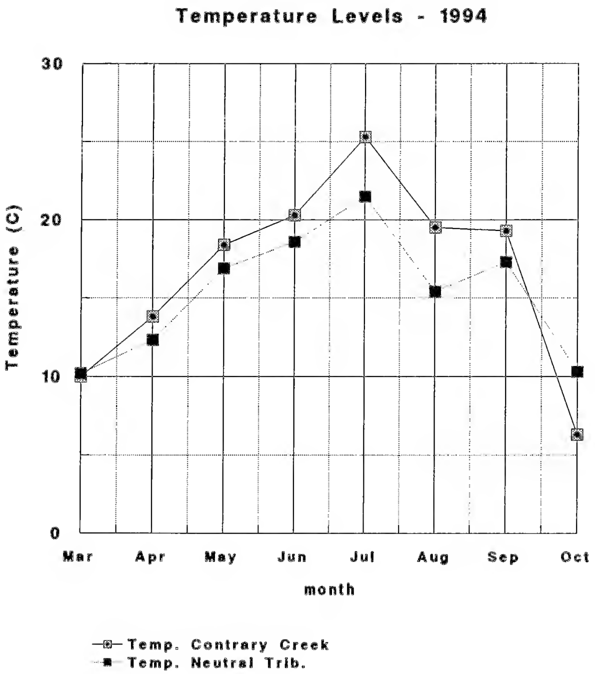

FIGURE 4. Temperature levels at Contrary Creek and the neutral tributary.

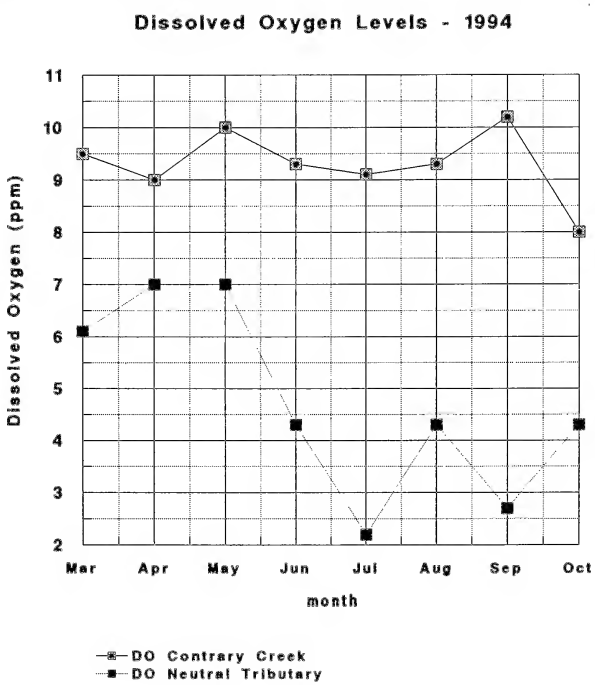

FIGURE 5. Dissolved oxygen levels at Contrary Creek and the neutral tributary.

transect in the stream channel using an Analytical Spectral Devices (ADS) PS II Spectroradiometer. Data collection followed the procedure outlined by Satterwhite and Henley, 1989. A five-degree field-of-view (FOV) is used to gather spectra in an eight centimeter sampling spot at a distance of one meter.

All spectra were collected at a nadir viewing angle in direct sunlight and referenced to a halon (Spectralon) standard. Three spectra were collected for each sample and then averaged. Late winter, summer and fall spectral reflectance data were analyzed to determine the seasonal spectral characteristics for acid and neutral bacterial precipitates (see Figures 6 & 7). Bacteria were collected and studied using non-standard microbial ecology methods. The precipitates were collected with an eyedropper and vial as well as by placing microscope slides into the creek and tributary stream. Light microscope observations of morphology were supplemented with standard microbial testing (broth tubes) for thiobacilli by Mark Stanton of the U.S. Geological Survey.

RESULTS

Acid stream bacteria in the orange-yellow precipitates within Contrary Creek included motile rods, non-motile cocci and short rods, and empty sheaths of filamentous bacteria resembling *Leptothrix ochracea*. Broth tube cultures were positive for NO_3 and Fe utilization, which is characteristic of *Thiobacillus*.

The spectroradiometric properties recorded for these precipitates (Figure 6.) show distinct and seasonally fluctuating waveform reflectance characteristics. Averaged spectral reflectance values for March through October showed that acid bacterial precipitates were 44% brighter than neutral bacterial precipitates. For the acid precipitates, reflectance peaks ranged from 750nm (March) to 711nm (September) over the course of the sampling period. This suggests a shift to shorter wavelengths from late winter to summer. Percent reflectances of 29 to 45 were also recorded. The highest reflectance values were measured over the late summer during August and September. At this time, pH levels were at their lowest point while specific conductivity levels were at their highest. Lower precipitate reflectance values for the bacteria were recorded during October, possibly in response to cooler temperatures and increased stream flow. Seasonal water quality measurements in the past suggest that Contrary Creek has had wide seasonal fluctuations in pH, temperature and conductivity. Our water quality measurements appear to be consistent with past gage station data.

Bacteria in the red precipitates occupying the neutral tributary were dominated by *Siderocystis* spp. in March. In April, *L. ochracea* dominated, *Toxothrix trichogenes* was next in abundance. *Gallionella ferruginea* also was present, but only weakly colored by thin iron-oxide precipitates in both March and April. Non-motile and motile cocci and colorless filaments were also present. The spectral properties of this neutral precipitate (Figure 7) exhibited reflectance peaks of 710nm (March) to 770nm (September) which are more red to far red spectrally. These values may suggest a shift to longer wavelengths from winter to summer. In addition, lower fluctuating reflectance values of 12 (March) to 25.5 (September) were measured. Again, the percent reflectance was seasonally dynamic with the brightest levels recorded during the summer and a decline in the fall. Water quality in the neutral drainage (pH, specific conductivity, and temperature) did not vary

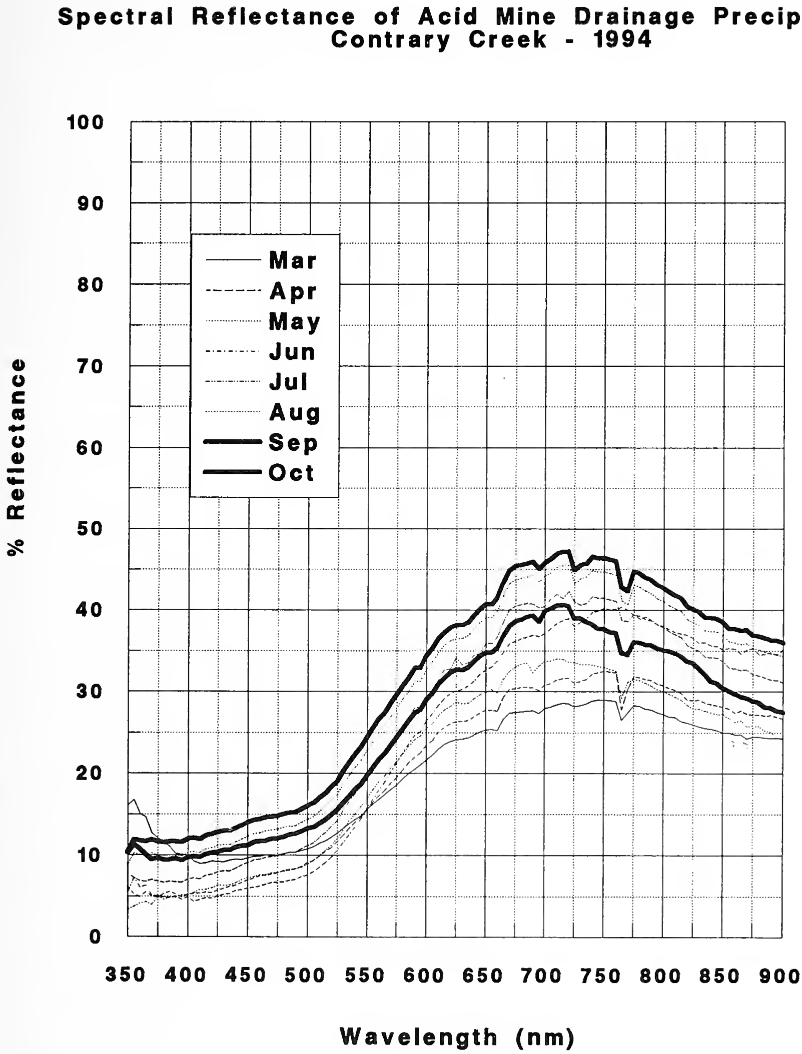

FIGURE 6. Spectral reflectance of acid mine drainage precipitates from March to October 1994.

widely, but wide variations in dissolved oxygen were recorded from winter to summer. This is probably due to this tributary emerging from an anoxic seep zone.

Following techniques described by Sokal and Rohlf (1981), linear regression equations (Figures 8 & 9) were used to investigate the possible relationships between acid and neutral reflectances and the measured water quality parameters. For both the acid and neutral precipitates a strong relationship between reflectance levels and specific conductivity emerges with an r^2 of 0.808 and 0.728, respectively. Relationships between reflectance, pH, dissolved oxygen, and temperature are not

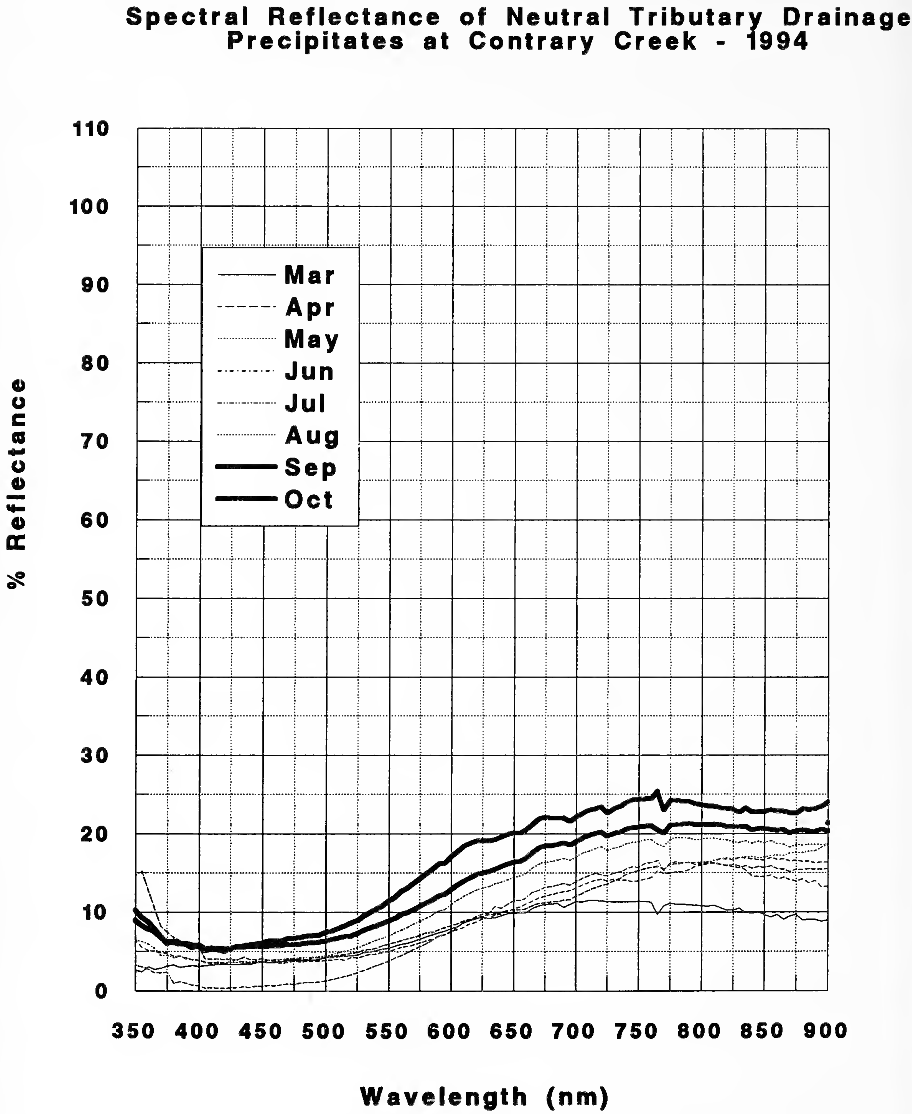

FIGURE 7. Spectral reflectance of neutral drainage precipitates from March to October 1994.

evident with r^2 values well under 0.40. The regression results suggest that specific conductivity levels may be predicted based upon reflectance values. Wetzel (1983) describes specific conductance as a parameter in determining water purity. Typically, as a function of ionic content, the lower the conductance, the purer the water.

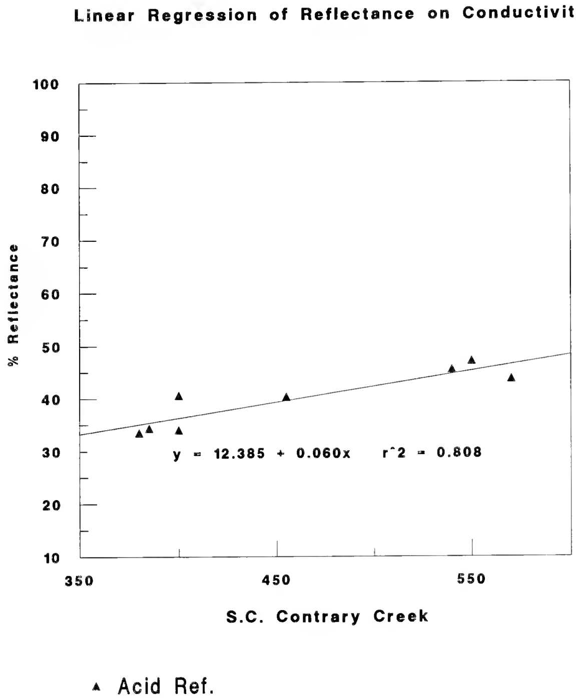

FIGURE 8. Linear regression of acid precipitate reflectance on specific conductivity.

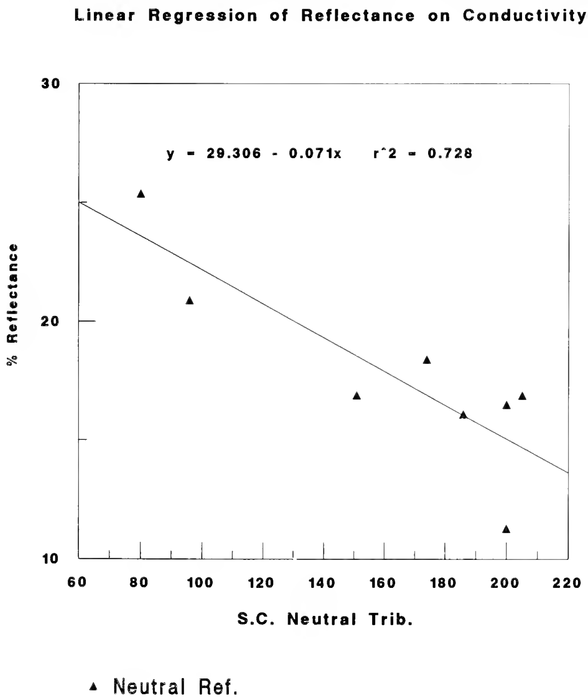

FIGURE 9. Linear regression of neutral precipitate reflectance on specific conductivity.

DISCUSSION

The microbial communities and their associated precipitates in the acid stream and neutral tributary were spectrally distinct and different. The orange-yellow precipitates, which had high reflectance values, were dominated by colorless rods typical of the acid-producing thiobacilli. The stream reach in which these measurements were collected was void of invertebrates and fish due to the consistently high acid conditions of the water. The reddish precipitates in the neutral tributary were characterized by very low reflectance values and had the usual consortium of iron depositing bacteria . This neutral tributary also was colonized by fly larva (Dixidae) and aquatic worms (Oligochaeta).

The disparity of acid- and neutral-precipitate seasonal spectral reflectance and its association with specific conductivity suggests that passive spectroradiometry has the capacity for evaluating acid and neutral drainages where the colors of these precipitates become confusing. Furthermore, it should be possible to predict both bacterial communities and conductivity levels based upon the spectral reflectance response of the precipitates.

Although more research and analysis is required to evaluate longer spatial and temporal influences on the spectral reflectance signatures of acid mine and neutral drainage precipitates, this investigation demonstrates that certain properties do exist and are associated with different water qualities. In watersheds where acid mine drainage is a problem, the spectral characteristics of these precipitates may be used to evaluate water quality using remote sensing.

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Abundance and Spawning Site Utilization of *Fundulus heteroclitus* at the Virginia Coast Reserve

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ABSTRACT

Abundance and spawning site utilization in a population of the mummichog, (*Fundulus heteroclitus*), were compared at regularly and irregularly-flooded mainland salt marshes at the Virginia Coast Reserve from April - November 1992. Mummichog abundance was greatest in June. Mummichogs comprised 83% of fishes collected on intertidal marsh surfaces. Significantly more mummichogs were collected at the regularly flooded marsh (ANOVA, $p = 0.007$). Young-of-the-year represented a greater proportion of total mummichogs collected (72%) at the regularly flooded marsh in comparison to the irregularly flooded marsh (61%). Mummichogs were more abundant in the lower intertidal zone relative to the upper intertidal. Mummichogs utilize empty shells of the ribbed mussel, (*Guekensia demissa*), as egg deposition sites in Virginia Coast Reserve marshes; however, egg distribution is patchy, and patterns were not readily discerned. These results support the contention that large-scale, intensive sampling is necessary to accurately quantify spawning site utilization in salt marsh populations of *F. heteroclitus*.

Key Words: Mummichogs, *Fundulus heteroclitus*, ribbed mussels, *Guekensia demissa*, salt marshes, Virginia Coast Reserve

INTRODUCTION

The mummichog (*Fundulus heteroclitus*), is a ubiquitous component of salt marsh nekton communities along the Mid-Atlantic coast. Production of this species in mid-Atlantic salt marshes is among the highest reported for fishes (> 40.7 g m^{-2} year^{-1}) and sub-adults may account for approximately 80% of total annual mummichog production (Merideth and Lotrich, 1979).

In the mid-Atlantic region, *F. heteroclitus* spawns in conjunction with spring tides, depositing its dessication - resistant eggs in empty shells of the ribbed mussel (*Guekensia demissa*) or attaching them to stems and leaves of *Spartina alterniflora* (Taylor and DiMichele, 1983; Able, 1984). Reproductive condition is highest for several days coincident with full or new moons (Taylor and DiMichele, 1980). This tidal synchrony ensures deposition of eggs in the upper intertidal zone, where they

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are least likely to be removed by tidal currents (Taylor et al.,1979). Egg hatching is triggered by appropriate conditions of submergence and low dissolved oxygen levels, but eggs may remain viable for up to 1 month exposed to air (Taylor et al., 1977; DiMichele and Taylor, 1980). Using *in situ* manipulations, Kneib (1993) demonstrated that growth rate was positively associated and mortality rate negatively associated with tidal flooding for successive cohorts of *F. heteroclitus* larvae in a Sapelo Island, Georgia salt marsh.

The primary objective of this study was to document relative abundance and distribution patterns of *F. heteroclitus* (primarily young-of-the-year) on the surface of two mainland salt marshes varying in hydroperiod (regular vs. irregular flooding) at the Virginia Coast Reserve Long-Term Ecological Research Site (VCR-LTER). A second objective was to quantify distribution and abundance of *F. heteroclitus* eggs on the surface of salt marshes within the VCR-LTER in order to determine if spawning site utilization within mainland marshes of the VCR-LTER was similar to that observed in other mid-Atlantic populations of *F. heteroclitus*.

SITE DESCRIPTION

Two salt marsh sites at the Virginia Coast Reserve were selected for study (Figure 1). The two marshes differed in surface topography and flooding regime. Site 1 was located along a 2nd order tributary of Phillips Creek. Vegetation type was typical of mid-Atlantic high marsh environments with *Salicornia virginica* and *Distichlis spicata* dominating from the forested upland boundary to the mid-marsh. From the mid-marsh to the creekbank, the short-form of *Spartina alterniflora* occurred. Medium to tall *S. alterniflora* occurred only in a narrow fringe surrounding intertidal rivulets at this site. Maximum flooding depth was generally < 10-15 cm and the upper marsh was flooded only during spring tides. The second site was located along a 1st order tributary of an unnamed tidal gut and was separated from Phillips Creek by a man-made causeway. This site, adjacent to a wooded area known locally as "The Hammocks" (hereafter referred to as "Hammocks Marsh"), flooded regularly in excess of 30 cm depth. At this site, *S. virginica* and *D. spicata* were restricted to a narrow band adjacent to the upland boundary. Short-form *S. alterniflora* progressively graded to tall form in the mid-low marsh.

METHODS

Abundance Patterns

Pit traps (Kneib 1984; Talbot and Able 1984) were used to collect mummichogs and other marsh-resident nekton at four stations along elevational transects at Phillips Creek Marsh and Hammocks Marsh. An individual trap consisted of an 11.4 liter plastic container placed into a pit dug into the marsh substrate. A 0.9 x 1.2 m length of 1.6 mm nylon mesh netting was placed into the trap as a removable liner. Four 85 gm pyramid sinkers were attached to the net in order to conform the liner to the bottom of the trap. Two 1.2 m lengths of 1.9 cm diameter PVC pipe were attached lengthwise to the mesh liner and used as brails to purse the net when removing the sample.

Three replicate traps, installed at each topographic level along a transect at each site, were sampled monthly at maximum predicted spring low tides from April through November, 1992. Organisms collected in traps were placed on ice

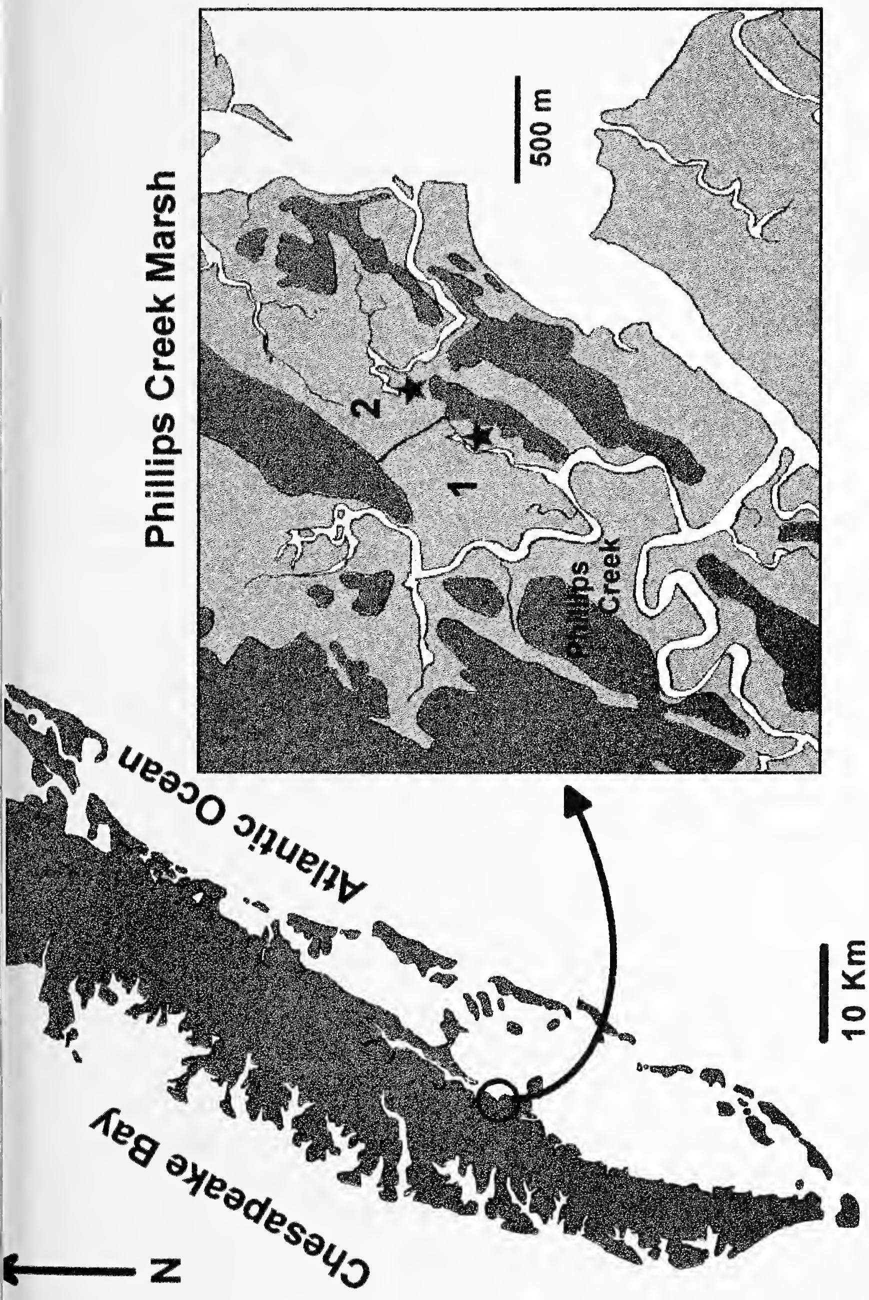

FIGURE 1. Map of the lower Delmarva peninsula and marsh study areas.

and returned to the laboratory for analysis. Unpreserved samples were sorted immediately following collection. All marsh-surface nekton (fishes and decapod crustaceans, excluding fiddler crabs (*Uca pugnax*) and marsh crabs (*Sesarma reticulatum*) were identified, counted, and preserved in 10% buffered formalin. Mummichogs were counted and measured to total length (mm).

Differences in abundance of mummichogs between the two study sites and between sampling stations within sites were tested by a repeated measures analysis of variance (ANOVA) model with MARSH and LEVEL as between subjects factors and MONTH as a within subjects factor. Abundance data were normalized using a log (y + 1) transformation (Sokal and Rohlf, 1981). *A priori* paired contrasts were used to compare selected means when significant differences were specified (α = 0.05).

The relative contribution of two age classes (young-of-the-year, adult) was determined by generation of frequency tables. Age/size class assignments were based on literature reported sizes for *F. heteroclitus* (Kneib and Stiven, 1978; Talbot and Able, 1984). Statistical analyses were performed using SuperANOVA and Statview II software for the Macintosh PC (Abacus Concepts, 1989).

Measurements of physico-chemical parameters (salinity, temperature, dissolved oxygen, pH) within marsh surface waters were taken on each sampling date at all sites using a temperature compensated refractometer, a stem thermometer, a YSI Model 57 Oxygen meter, and a Hanna portable pH meter.

Spawning Site Utilization

Permanent 100 m longitudinal transects were established within each of the four elevational strata at Phillips Creek Marsh and Hammocks Marsh. Two spawning substrates were examined for the presence of *F. heteroclitus* eggs. Empty ribbed mussel shells were collected without replacement from randomly selected 1 m^2 sample plots along each transect on June 4, June 15, July 2 and August 4. Shell width (length of long axis, in mm) was measured for each empty shell (Taylor and DiMichele, 1983). Live mussels were censused from each sample plot in order to determine the relative availability of mussel shells as spawning sites at each topographic stratum. Six plots per transect were sampled on June 4 and June 15 and sampling effort was increased to 8 plots per transect for the latter two sampling dates due to the patchy distribution of empty shells. Additional mussel shells were collected on June 5 from 100 m^2 permanent plots located at the upper boundary of the low marsh at each site. In addition, *Spartina alterniflora* stems were harvested from each 1 m^2 plot on all sampling dates. In the laboratory, *S. alterniflora* stems and contents of mussel shells were carefully rinsed onto a # 60 (250 μm) brass soil sieve and examined for *F. heteroclitus* eggs. All eggs collected were preserved in 10% buffered formalin. Stem density of emergent vegetation (primarily *S. alterniflora*) was measured along all transects on June 8.

RESULTS AND DISCUSSION

Abundance Patterns

Fundulus heteroclitus comprised 83% of all fishes collected. Additional marsh resident fish species collected in traps included spotfin killifish (*Fundulus luciae*) and naked gobies (*Gobiosoma bosci*). Daggerblade grass shrimp (*Palaemonetes

pugio), juvenile blue crabs (*Callinectes sapidus*), and juvenile big-clawed snapping shrimp (*Alpheus heterochaelis*) also frequently occurred in pit traps.

A total of 634 mummichogs were collected in pit traps from April through November, 1992. In general, mean abundance was greatest at creekbank and low marsh stations, with decreasing abundance at high marsh and marsh/upland interface stations (Figure 2). Abundance peaked in June, when large numbers of post-larvae and early juveniles were present on the marsh surface. Overall, young-of-the-year comprised 72% of all mummichogs collected at Hammocks Marsh, and 61% of mummichogs collected at Phillips Creek Marsh. Significantly more mummichogs (66% of total) were collected at Hammocks Marsh (ANOVA, $p = 0.007$), many of which (37% of total) were collected from the low marsh station (Table 1). At Hammocks Marsh, significant differences were observed between the marsh/upland interface, where relatively few fishes were collected, and all other stations (Table 2). At Phillips Creek Marsh, significant differences in abundance were observed between the marsh/upland boundary and the high marsh and creekbank stations. Relatively few mummichogs were collected in the low marsh at Phillips Creek. Recruitment to the marsh surface and/or spawning activity appears to have occurred earlier at Hammocks Marsh, as indicated by greater abundance of YOY in April - June. After July, however, mean monthly abundance was slightly greater at Phillips Creek Marsh.

Surface water physico-chemical parameters did not differ markedly between the two study sites (Table 3). The major difference between the two sites was variation in hydroperiod. Our observations indicate that Hammocks Marsh flooded regularly to a depth of approximately 30 cm. In contrast, Phillips Creek Marsh was generally flooded only on spring tides and average flooding depth was relatively low ($\approx$ 10 - 15 cm). The two marshes were subsequently instrumented with Qualimetrics Richards-Type water level recorders. Measurements obtained during the following field season (August - December, 1993) confirm our earlier observations on flooding frequency/depth at these locations (Yozzo, 1994) . Kneib (1993) experimentally determined that growth rate was positively correlated with flooding duration in a Sapelo Island, Georgia population of *F. heteroclitus*. Our abundance and size-distribution data indicate greater recruitment and survivorship at Hammocks Marsh, a regularly flooded site. Differential patterns of habitat use by larval and juvenile *Fundulus* spp. were described by Yozzo et al., (1994) in a comparison of mainland (Phillips Creek Marsh) and back-barrier marshes at the VCR. Observed patterns of sub-adult finfish abundance were attributed to variation in hydroperiod and the relative availability of high marsh nursery habitat.

Spawning Site Utilization

A total of 1706 *F. heteroclitus* eggs were collected from transects and 100 m^2 mid-marsh plots, and although eggs were collected at both sites, abundance was extremely patchy, and often a single shell would yield large numbers of eggs. Previous workers (Able and Castagna, 1975; Taylor and DiMichele, 1983) have reported that individual ribbed mussel shells may be utilized as egg deposition sites by multiple spawning females .

Live mussels were most abundant at the low marsh and creekbank transects at Phillips Creek. At the Hammocks, mussels were most abundant in the high marsh

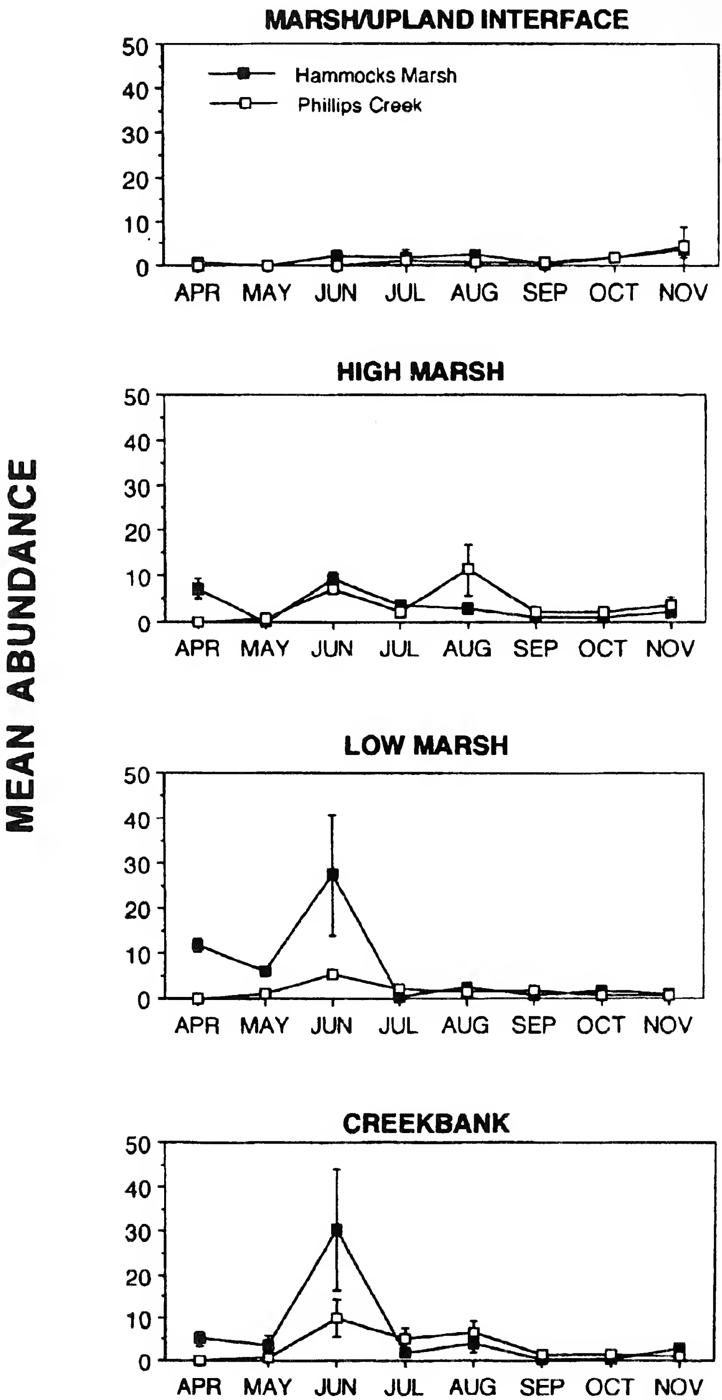

FIGURE 2. Mean monthly abundance of *Fundulus heteroclitus* on the surface of Hammocks Marsh and Phillips Creek Marsh; April - November, 1992.

TABLE 1. Repeated Measures ANOVA comparing *Fundulus heteroclitus* abundance between marsh sites and topographic levels.

Source	SS	df	MS	F	p
Marsh	0.636	1	0.636	9.541	0.0070
Level	2.163	3	0.721	10.822	0.0004
Marsh x Level	0.410	3	0.137	2.052	0.1471
Month	6.990	7	0.999	21.994	0.0001
Month x Marsh	4.271	7	0.610	13.440	0.0001
Month x Level	4.759	21	0.227	4.992	0.0001
Month x Marsh x Level	2.372	21	0.113	2.488	0.0011

TABLE 2. Results of *a priori* ANOVA paired contrasts comparing abundance of *Fundulus heteroclitus* between the Marsh/Upland Interface and other topographic levels (High Marsh, Low Marsh, Creekbank) at Phillips Creek Marsh (PC) and Hammocks Marsh (HAM) *Significant at = 0.05.

		p
PC	MUI x HM	0.0006*
	MUI x LM	0.1098
	MUI x CBK	0.0015*
HAM	MUI x HM	0.0133*
	MUI x LM	0.0029*
	MUI x CBK	0.0082*

TABLE 3. Ranges and means of physico-chemical parameters from Phillips Creek Marsh and Hammocks Marsh, April - November, 1992.

	Salinity (ppt)	Temp. (^{o}C)	pH	DO (mg/l)
Phillips Creek Marsh	30 - 45 (38)	17 - 35 (25)	7.9 - 8.6 (8.1)	2.8 - 13.3 (8.6)
Hammocks Marsh	30 - 38 (34)	13 - 34 (23)	6.8 - 8.6 (7.7)	2.3 - 12.1 (8.4)

and low marsh zones. Empty shells were scarce in transect plots (n = 48), however, all transects yielded empty shells except for the upland boundary at Phillips Creek. Thirteen eggs were found in shells from the creekbank zone at Hammocks Marsh. All of the eggs collected from the low marsh at Phillips Creek (n = 657) were from a single shell (Table 4).

Few eggs attached to *Spartina alterniflora* stems were collected in the intertidal zone; four were collected at the marsh/upland interface at Phillips Creek, where

TABLE 4. Abundance and distribution of live ribbed mussels, total abundance and mean width (mm ±1SE) of empty mussel shells, and total abundance of *Fundulus heteroclitus* eggs at Phillips Creek Marsh and Hammocks Marsh, June - August 1992*.

Site	Total Live Mussels	Total Empty Shells	Mean Shell Width (mm)	Total Eggs
Phillips Creek Marsh (irreg. fl.)				
Marsh-Upland Interface	0	0	0	4 **
High Marsh	36	2	72.5 ±14.5	0
Low Marsh	174	7	76.4 ±7.4	657
Creekbank	167	9	89.6 ±4.9	0
Hammocks Marsh (reg. fl.)				
Marsh-Upland Interface	19	4	85.0 ±4.4	0
High Marsh	232	15	82.1 ±5.0	0
Low Marsh	299	5	91.8 ±8.6	1 **
Creekbank	172	6	86.2 ±6.6	13

* sum of collections made on June 4, July 2, July 15, and August 4.
** eggs found attached to *S. alterniflora* stems

G. demissa does not occur. Mean stem density was highest at this location (Table 5). A single egg was collected in the low marsh transect at Hammocks Marsh.

Collections at the Hammocks Marsh 100 m^2 plot on June 5 yielded 29 empty shells; only 4 empty shells were recovered from the Phillips Creek Marsh plot. Shell width at the Phillips Creek Marsh plot ranged from 75 - 102 mm (mean = 90.0 ±5.5). Shell width ranged from 57 - 106 mm (mean = 89.0 ±1.8) at Hammocks Marsh. A total of 1031 eggs were found in empty shells from the Hammocks Marsh plot. Number of eggs per shell ranged from 0 - 613 (mean = 35.5 ±22.8). No eggs were found in mussel shells from the Phillips Creek Marsh 100 m^2 plot.

Ripe egg counts from female mummichogs further indicate that individual mussel shells may be used as a substrate by multiple females during spawning events (Taylor and DiMichele, 1983). A mature female may produce 100 - 300 eggs per day early in the spawning season (Taylor, 1986).We have observed a maximum of 254 mature ova in a single female (97 mm TL) from > 150 individuals examined at the Virginia Coast Reserve in 1991-92. Hildebrand and Schroeder (1928) counted 460 mature ova in a 98 mm specimen from Chesapeake Bay. Taylor and DiMichele (1983) and Able and Castagna (1975) reported maximum egg counts of 630 and 718 in a single shell, respectively. We occasionally observed > 600 eggs in individual shells from both marsh sites. Additional collections from back-barrier salt marshes at the Virginia Coast Reserve have yielded extremely high densities (> 2500 eggs per shell). These observations suggest a greater degree of *G. demissa* shell utilization at back-barrier marsh sites relative to mainland sites.

TABLE 5. Emergent stem densities (mean no. stems m^2 1SE) at Phillips Creek Marsh and Hammocks Marsh transects, June 4, 1992.

Site	stem density (no. stems m^2)
Phillips Creek Marsh (irreg. fl.)	
Marsh-Upland Interface	714.7 ± 312.8
High Marsh	298.7 ± 29.7
Low Marsh	192.0 ± 40.3
Creekbank	192.0 ± 42.3
Hammocks Marsh (reg. fl.)	
Marsh-Upland Interface	437.3 ± 190.3
High Marsh	189.3 ± 25.4
Low Marsh	78.7 ± 27.6
Creekbank	86.7 ± 3.5

Previous investigators have reported that selection of suitable shells for egg deposition depends on orientation and gape width; eggs are deposited only in shells oriented vertically with a gape width of 0.5 - 5 mm, thereby affording protection to fertilized eggs from dessication and predation/cannibalism (Able, 1984; Taylor, 1986). Although not measured in this study, variation in gape width may account for the observed lack of eggs in otherwise suitable shells. Previous workers (Able and Castagna, 1975) reported that egg deposition was likely to occur only in shells > 60 mm in width. Shells < 50 mm were never utilized as egg deposition sites in Delaware marshes (Taylor and DiMichele, 1983) or in Virginia mainland marshes.

Results presented here are similar to those reported by Taylor and DiMichele (1983) in their investigation of spawning site utilization by *F. heteroclitus* in a Delaware salt marsh. They surmised that *S. alterniflora* stems were probably used as a secondary spawning site by *F. heteroclitus*, and that egg deposition on *S. alterniflora* stems and leaves was likely to be of greater significance in low salinity coastal marshes where *G. demissa* did not occur. In a related study, we have observed widespread deposition of eggs at the base of Arrow-arum (*Peltandra virginica*) stems in a tidal freshwater population of *F. heteroclitus* residing in marshes contiguous with the Chickahominy River, Virginia.

CONCLUSIONS

Fundulus heteroclitus was significantly more abundant at The Hammocks Marsh site, where regular tidal flooding may enhance survival and growth of marsh-resident nekton. Relative abundance of mummichogs (primarily YOY) was greater at creekbank and low marsh stations.

Mummichogs preferentially utilize empty shells of *Guekensia demissa*, which are abundant and widely distributed on the surface of VCR salt marshes, as egg deposition sites. As documented elsewhere, occurrence of eggs on the marsh surface is patchy, and patterns of distribution and abundance are not readily discerned.

The results of this study concur with those of previous workers (Taylor and DiMichele, 1983) and support the recommendation that large-scale, intensive sampling is necessary to accurately identify patterns of egg deposition by *F. heteroclitus* on the surface of salt marshes.

ACKNOWLEDGEMENTS

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VIRGINIA ACADEMY OF SCIENCE
EXECUTIVE COMMITTEE MEETING MINUTES

May 20, 1994

Present:Elsa Q. Falls (President), Thomas O. Sitz (President-Elect), Rosemary Barra (Secretary), Kenneth C. Jacobs (Treasurer), Don Cottingham (VJAS Director), Arthur W. Burke, Jr. (Assistant to the Executive Secretary-Treasurer), Golde Holtzman (1992-93 President), Gerald Taylor (1991-92 President)

The meeting was called to order at 8:30 AM. Following introductory remarks by President Elsa Falls, the agenda for the meeting was adopted. The minutes from the Executive Committee meeting of May 18th were not available and they will be acted on at the Fall Council meeting.

OFFICERS' REPORTS

President - Elsa Q. Falls

President Falls distributed the list of VAS Committee assignments for 1994-95. She indicated that the list will be modified to include the names of the students elected as VJAS officers and to include the members of the 75th Anniversary Committee which is still being formed. Golde Holtzman is the chair of that committee.

President Falls announced that the following reappointments need to be approved by Council, and that the appropriate motions will be made at the Council meeting.

Paul J. Homsher - Trust Committee
Blanton M. Bruner - Executive Secretary-Treasurer
Arthur W. Burke, Jr. - Assistant to the Executive Secretary-Treasurer
Don Cottingham - VJAS Director
Ertle Thompson - AAAS Representative

The proposed VAS Schedule of Responsibilities 1994-95 was distributed to the members. President Falls also requested suggestions of possible speakers for next year's annual meeting.

President-Elect - Thomas O. Sitz

No report

Secretary - Rosemary Barra

No report

Treasurer - Kenneth C. Jacobs
No report

Past President - James P. O'Brien

Absent

VJAS Director - Donald R. Cottingham

The Junior Academy meeting went very well this year, and a number of individuals indicated that it was the best meeting that they had ever attended.

President Falls reminded everyone that finding a successor for Don was the responsibility of the Executive Committee, and that work on this should begin immediately since he wished to be relieved of his duties at the end of May 1995.

EXECUTIVE SECRETARY-TREASURER - Blanton Bruner

Arthur Burke reported that Blanton Bruner was unable to attend the annual meeting this year and that he sends his regards. The CPA audit of the Academy for 1993 indicates that the Academy is financially in good shape. The total assets of the Academy as of December 31, 1993 were $342,287. This represented an approximately 9% increase over the total assets of $315,323 on January 1, 1993.

Art requested that the Executive Committee consider a change in the bylaws that would allow withdrawal of funds to a certain limit without excessive documentation. The need for this occurs when a budget item exceeds the budgeted amount and Blanton writes a check to cover the amount. President Falls suggested that Art discuss this issue with Gerald Taylor to determine the correct wording for the bylaw change, and that it be brought to the Executive Committee at its Fall meeting.

LOCAL ARRANGEMENTS COMMITTEE REPORTS

President Falls reported that Rae Carpenter was not able to attend today's meeting and that R.B. Minnix would report at the Council meeting. Don Cottingham requested that the costs associated with next year's meeting, room costs and fees, be set early next year. President Falls indicated that the rates will be set at the January 20th meeting. She also indicated that representatives of the Local Arrangements Committee for next year's meeting will be present at the Summer VJAS Committee Meeting to further discuss the problems involved in housing the Junior Academy at VMI.

OLD BUSINESS

Motions involving changes to the Bylaws will be introduced at the Council meeting.

A motion to approve Natural History and Biodiversity as a new section will be made at the Council meeting.

ANNOUNCEMENTS

James P. O'Brien, who joined the meeting, thanked the Executive Committee, Gerald Taylor, Golde Holtzman, Don Cottingham, Elsa Falls, and Art Burke for all their help during the year that he was President of the Academy.

The meeting was adjourned at 9:15.

VIRGINIA ACADEMY OF SCIENCE COUNCIL MEETING MINUTES

May 20, 1994

Present:Elsa Q. Falls (President), Thomas O. Sitz (President-Elect), James P. O'Brien (Past President, 1993-94), Rosemary Barra (Secretary), Kenneth C. Jacobs (Treasurer; Councilor, Astronomy, Math and Physics Section), Donald R. Cottingham (VJAS Director), Golde I. Holtzman (Past President, 1992-93; Chair, Archives Committee and 75th Anniversary Committee), Gerald R. Taylor (Past President, 1991-92; Co-Chair, Constitution and Bylaws Committee), Vera B. Remsburg (Trustee, Science Museum of Virginia), James H. Martin (Editor, Virginia Journal of Science), Judy Niehaus (Chair, Research Committee), Robert A. Berquest (Councilor, Psychology Section), Carolyn B. Conway (Chair, Awards Committee; Councilor, Biology Section), Barry Knisley (Chair, Natural History and Biodiversity Section), Greg Cook (Editor, Virginia Scientists; Chair, Computer Science Section); J. Mark Wittkofski (Councilor, Archaeology Section); Thomas G. Teates (Councilor, Education Section; Co-Chair, Science Education Committee), W. Cullen Sherwood (Councilor, Geology Section), William P. Harrison (Secretary, Biomedical and General Engineering Section), Ertle Thompson (AAAS Representative), Arthur W. Burke, Jr. (Chair, Finance and Endowment Committee; Assistant to Executive Secretary-Treasurer), Marion B. Lobstein (Councilor, Botany Section; Co-Chair, Public Affairs Committee), Richard Brandt (Chair, Long Range Planning Committee), Charles O'Neal (Secretary, Microbiology and Molecular Biology Section), Richard B. Minnix (Co-Chair, Local Arrangements Committee - VMI), R. Dean Decker (Past VJAS Director).

The meeting was called to order by President Elsa Falls at 9:35 AM, and a motion to accept the agenda was approved. Minutes from the last Council meeting on May 18, 1994 were not available and will be acted on at the Fall Council Meeting.

OFFICERS' REPORTS

President - Elsa Q. Falls

Copies of the 1994-95 VAS Committee assignments were distributed, and President Elsa Falls indicated that a few modifications will be made in the list the addition of the VJAS officers and the members on the 75th Anniversary Committee which is still being formed.

The term of Paul J. Homsher on the Trust Committee having expired, Ertle Thompson moved that he be reappointed. This motion was seconded by Gerald Taylor and passed unanimously by Council.

President Falls distributed the proposed VAS Schedule of Responsibilities for 1994-95. Ertle Thompson asked when the address change for the Executive Secretary -Treasurer will go into effect. It was decided that the change will occur

after the actual move to the Science Museum this summer, and that an announcement will be placed in the Virginia Scientists.

President Falls also requested input from the members of Council for possible speakers at next year's annual meeting.

President-Elect - Thomas O. Sitz

No report

Secretary - Rosemary Barra

No report

Treasurer - Kenneth C. Jacobs

No report

Executive Secretary-Treasurer - Blanton Bruner

President Falls indicated that Blanton Bruner and Arthur Burke needed to be reappointed as the Executive Secretary-Treasurer and Assistant to the Executive Secretary-Treasurer respectively. Gerald Taylor made the motion to reappoint Blanton Bruner and Arthur Burke which was seconded by Don Cottingham and unanimously approved by Council.

Arthur Burke reported that the auditors' report showed that the Academy is in good financial standing with a gain of approximately $27,000 during 1993. This gain was due primarily to the actions of the Trust Committee and the performance of the stock market.

Past President 1993-94 - James O'Brien

Absent (he joined the meeting later)

Past President 1992-93 - Golde Holtzman

No report

Past President 1991-92 - Gerald Taylor

No report

LOCAL ARRANGEMENTS COMMITTEE REPORTS

H. Kent Moore and Diane M. Spresser from James Madison University reported that the annual meeting was going well and presented the following statistics on the number of people attending the meeting.

VJAS		VAS	
Paid Participants	860	Pre-registered	310
Parents & Friends	110	Registered on Site	120
TOTAL	970	TOTAL	430

Approximately 30 of the on site registrants also became new members.

They reported on two problems they encountered while organizing the annual meeting. The first involved the insurance coverage for the meeting. The insurance premium for the meeting was approximately $400. The insurance agent suggested that the Academy should carry a blanket coverage rather than a policy that just covers the meeting, and that this policy would be less expensive. The other problem concerned getting local help. They pointed out that students were not available since classes were not in session, and that they were given some tasks that were difficult to manage due to the lack of help.

President Falls thanked Kent and Diane for all of their hard work and indicated that she will work to take care of the problems for next year.

Marion Lobstein asked that in the future when room assignments are being made for the different sessions that an effort be made to keep sections with similar interests in the same building. This year it was impossible to attend some papers since the meeting rooms were sometimes far apart.

Dick Minnix reported for the 1995 Local Arrangements Committee from VMI. He indicated that the subcommittees have already been organized for next year's meeting, and that they will be working on the housing problems involving the junior academy and Natural Bridge. They will report on their progress at the summer VJAS meeting.

SECTION REPRESENTATIVE'S REPORTS

Aeronautical and Aerospace Science
Absent

Agriculture, Forestry and Aquaculture
Absent

Archaeology - J. Mark Wittkofski
It has been a good meeting, attendance has increased and we look forward to next year.

Astronomy, Mathematics, and Physics - Kenneth C. Jacobs
Today's session is still in progress. They had 24 papers and 2 posters in their session including 11 student presentations.

Biology - Carolyn M. Conway
The Biology Section had 23 oral presentations and 12 posters. During the section meeting, concerns were voiced again about the fact that students who come as observers are required to pay a registration fee. Dean Decker commented that at all national meetings student observers are required to register and pay. Richard Brandt observed that each section can get up to $100 from the Academy and if they wished could use these funds to pay the registration fees for student observers.

Concerns were also raised about the scheduling of poster sessions concurrently with paper presentations which prevented members of the section from attending both types of presentations. Possibly the poster sessions could be scheduled during a wine and cheese reception or some other function so that they would not conflict with the oral presentations.

Biomedical and General Engineering - William P. Harrison
Good meeting with many good papers.

Botany - Marion Lobstein

A total of 26 papers and posters were presented at this year's meeting. They were disappointed that the VJAS winner did not show up to present at the section meeting and requested that the section be notified if the student is not going to attend.

Don Cottingham described the problems associated with notifying the student presenters and the short time interval between the announcement and the actual presentation. It was suggested that maybe the sponsor could be notified on Wednesday night so that the student would be prepared to give the presentation on Thursday morning after the awards ceremony. Don will pursue this issue.

Marion also reported that they enjoyed the trip to the Arboretum and they are looking forward to field trips next year at VMI.

Chemistry - Thomas O. Sitz
This meeting was the best in recent years. The VJAS student presentation involving Enzyme Kinetics was excellent.

Computer Science - Greg Cook
Successful meeting

Education - Thomas Teates
This was a good meeting, and the student papers were excellent. One situation came up concerning a group called the Virginia Science Leadership Association. They asked for space on our program but it was after the schedule had already been submitted. They ended up meeting at the same time, and since we share many common interests a conflict was created in which some of the members of both organizations had to choose which meetings to attend. We will explore ways to deal with this conflict before next year.

Environmental Science
Absent

Geography
Absent

Geology - W. Cullen Sherwood
Fifteen papers were scheduled, and the attendance was higher than last year.

Materials Science
Absent

Medical Science
A total of 43 papers were scheduled this year, and the meetings will be going on until 3:30 this afternoon.

Microbiology and Molecular Biology
This year only 3 papers were submitted because of the conflict with the national meeting. These papers were moved to the Medical Science Section, and the Microbiology Section did not meet.

Psychology - Robert A. Berquest
This year 39 papers were presented. The section needs to consider having poster presentations in the future. We also hope to look at ways to encourage participation by institutions that participated in the past but are not present now.

Statistics
This year there was a decrease in attendance. The new officers of the section will work to increase participation.

PROPOSED SECTION - NATURAL HISTORY AND BIODIVERSITY

Barry Knisley reported that the Natural History and Biodiversity proposed section had a successful meeting, and that 16 papers, 1 poster and 2 student presentations were made. Since they have now met the requirement of having one successful meeting, this group wishes to become an official section of the Academy. James O'Brien moved that Natural History and Biodiversity become a section of

the Virginia Academy of Science. This motion was seconded by Don Cottingham.

Carolyn Conway commented on behalf of the Biology Section. Members of the Biology Section are concerned about the overlap between this new section and Biology, and she indicated that as the representative of the Biology Section she would vote against establishing this new section. Arthur Burke noted that in previous years the number of papers in the Biology section required that two concurrent sessions were run. The Biology section appears to be very healthy. James O'Brien noted that some of the presentations that he would expect to be presented in the Psychology section were presented instead in the Medical Science section. Overlap in interests between different sections is to be expected.

James Martin called for the question and the motion passed with one negative vote.

It was suggested that the section secretaries of Biology, Botany and Natural History and Biodiversity consult with each other when they prepare the schedule for next year so that papers that would appeal to the same people are not presented at overlapping times.

DIRECTORS' AND REPRESENTATIVES' REPORTS

VJAS Director - Don Cottingham

President Falls announced that Don Cottingham needed to be reappointed by Council as the Director of the VJAS. Ertle Thompson moved and Art Burke seconded the reappointment of Don Cottingham. This motion was passed unanimously by Council. Elsa Falls announced that Don was planning on retiring from this position after the 1995 Annual meeting and that plans are being made to look for a new director.

Don Cottingham reported that this year's meeting was very successful, and that they had made a few changes. They allowed parents who drove in for the day to attend the presentations of their children without being charged. They also included lunch on Thursday in the package. This was done to encourage the students to attend some of the meetings of the Senior Academy.

The summer meeting at Graves Mountain Lodge will be held the third Saturday in July, and will deal with the regionalization plan. The director of the Ohio Junior Academy will be the speaker. At this meeting they will discuss the possibility of having joint papers presented at future meetings. The problems associated with housing at VMI will also be addressed and, as stated before, members of the Local Arrangement Committee for VMI will attend this meeting.

President Falls thanked Don for all his hard work.

Visiting Scientist's Program - Jack Cranford

Absent

AAAS Representative - Ertle Thompson

Gerald Taylor moved that Ertle Thompson be reappointed as AAAS Representative for the term specified in the bylaws which is consistent with the AAAS term. This motion was seconded by Don Cottingham and unanimously approved by Council.

Ertle Thompson had no report beyond what was presented at Wednesday's council meeting.

Science Museum of Virginia - Trustee Vera Remsburg

No report

Jeffress and Gwathmey Memorial Trust Allocations Committee Representative

Richard B. Brandt

James O'Brien moved that Richard Brandt be reappointed as the Representative to the Jeffress and Gwathmey memorial Trust Allocations Committee. This motion was seconded by Gerald Taylor and passed unanimously by Council.

STANDING COMMITTEE REPORTS

Archives Committee - Golde Holtzman

Golde Holtzman reported that Charlotte Webb met with the Fellows, and gave them a progress report on the VAS history she is writing. Golde also reminded Council that the proceeds from the sale of the book on the James River go to the Fellows.

Awards Committee - Carolyn Conway

As of this morning, the VAS presented 9 best student papers awards, 9 honorable mentions and 1 poster award (in Biology). More awards will be made after the meetings today.

Constitution and Bylaws - Gerald Taylor

Gerald Taylor distributed to the members of Council a document entitled "Amendments to the Bylaws of the Virginia Academy of Science as approved at its Spring 1994 meeting" (attached). These amendments have been approved. The constitution changes indicated on the document entitled "Constitution Changes

Approved by Council and Distributed to Membership as Directed by the Virginia Academy of Science Constitution" (attached) have been passed at the Academy Conference.

The Constitution and Bylaws Committee moved that Article II: Duties of Officers Section 2 and 3 of the bylaws be passed (attached). These bylaws were reviewed by Council at its February meeting and were distributed to the membership of the Academy. This motion was unanimously approved by Council.

Gerald Taylor also distributed a document entitled "Proposed Bylaws Changes Approved by Spring 1994 Council for Distribution to Membership" (attached). The Constitution and Bylaws Committee moves that Council approve the following Bylaws: Article III: Duties of Standing Committees, Article XIII: Virginia Scientists Newsletter and Article XIV: Official Abbreviations. This motion was unanimously approved by Council.

President Falls thanked Gerald Taylor and Michael Bass for their work on the Constitution and Bylaws.

<u>Environment - J.J. Murray</u>

Jim Murray was absent since he was attending the World Watch Conference. James O'Brien reported that approximately 35 people were at the Conference.

<u>Finance and Endowment - Arthur W. Burke, Jr.</u>

The Academy is financially in good shape and currently has assets in the neighborhood of three times its annual liability.

<u>Fund Raising - James O'Brien</u>

Will present plan in November.

<u>Long Range Planning - Richard B. Brandt</u>

Tom Haas, the Local Arrangements Chair for the 1996 meeting at VCU, has been invited to attend the Local Arrangements Meeting at VMI. ODU will host the 1999 Annual Meeting.

<u>Membership and Public Affairs Committees - Marion Lobstein</u>

Marion indicated that the Committee is discussing ways to increase membership and will possibly target community colleges, minority institutions and high school teachers. No teachers signed up for the Continuing Education Credit (attached), but they will work on this again next year. The new membership pamphlet is available. It was also suggested that space be allowed so that the name of any new

sections could easily be added in the future. Marion indicated that the pamphlet is on computer and can easily be changed.

Nominations and Elections Committee - Gerald Taylor

Gerald Taylor requested that he be sent nominations for President-Elect, Vice President, Treasurer and Secretary.

Publications - James Martin and Greg Cook

Jim Martin indicated that the next issue of the Virginia Journal of Science will be out in about one month. He requested that more papers be submitted for publication.

Greg Cook asked for information that can be placed in the Newsletter. This information can be sent to him either via E-mail or on disc. July 15th is the deadline for the next issue.

Research - Judy H. Niehaus

Tom Sitz, as out going chair of the committee, indicated that they will soon finalize the small project grants. Judy Niehaus encouraged people to apply for the grants next year.

Science Advisory - William L. Dewey and Ernest R. Stout
Absent

Science Education - Thomas G. Teates and Maurice P. Lynch

No report

Arthur Burke commented on the VQUEST program. He participates in this program, and believes that it is accomplishing its mission and is set for about three more years.

Virginia Flora - Marion Lobstein

The meeting yesterday went well and we are still working on updating an atlas. A concern of the committee is how to improve botanical education at the college level as well as through the primary and secondary schools.

75th Anniversary Committee

James O'Brien indicated that the committee was still being formed and that Golde Holtzman will be the chair of the committee. Golde stated that during the next six months the committee will be setting its goals, and if anyone has any ideas they are welcome to join the committee.

OLD BUSINESS
None
NEW BUSINESS

Don Cottingham commented that the Virginia Association of Science Teachers would like to have on their Council a representative from the VAS. Don stated that as an organization VAS is not working to solve the problems associated with science education and that VAST and VSLA do not have the political clout needed to effect the decisions that are being made. He suggested that the organizations involved must consolidate their efforts in order to deal with the problems of science education in the state of Virginia.

Arthur Burke made the motion that this topic be moved to the Long Range Planning Committee for immediate attention. James O'Brien stated that this issue should be handled instead by the Science Advisory and Science Education Committees. After further discussion, Art Burke withdrew his motion. James O'Brien then made a motion to remand to the Science Advisory and Science Education Committees the issues relevant to the VSLA and VAST and that the president appoint representatives to these two organizations as she sees fit. This motion was seconded by Richard Brandt and unanimously approved by Council. These committees were asked to report on this issue at the Fall Council meeting.

The meeting was adjourned at 11:45.

ANNOUNCEMENTS

Environment Virginia '95 announces conference dates for April 6-7 1995 at Virginia Military Institute in Lexington, VA. The annual conference provides a forum for current environmental topics and networking for technology transfer. This year's focus will be on making pollution prevention relevant to localities. The first day, devoted to topics dealing with the state of the environment in Virginia, will be presented by the Department of Environmental Quality. The second day is organized by VMI Research Laboratories, Inc. and will focus on pollution prevention for agriculture, businesses and communities. The conference features exhibits, presentations, workshops and seminars. Advance registration is $75 until Dec. 31 ($95 from Jan. 1, 1995). Further information on registration, papers, exhibiting or sponsorship can be obtained from Capt. Ronald Erchul, Dept. of Civil & Environmental Engineering, Virginia Military Institute, Lexington, VA 24450 (telephone: (703) 464-7331 or 464-7743).

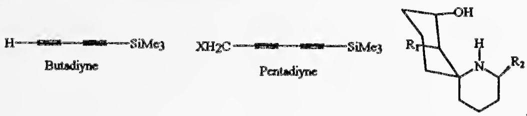
Abstracts ommited from the proceedings issuue because of mail problems.

Biology

MODULATION OF PLANARIAN REGENERATION BY CAFFEINE
Sophia C. Worobec* and Roman B. Worobec, Biomed. Res. Consults., POB 162, Mt. Vernon, VA 22121-0162. Exposure of a sexual variety of decapitated *Dugesia tigrina* to caffeine (11-220 mcg/ml) was shown to modify the course of regeneration as monitored by unambiguous eyespot appearance under 40X magnification. The most telling results were that regeneration was accelerated by constant exposure to 55 mcg/ml of caffeine, whereas 220 mcg/ml precluded regeneration. When caffeine exposure was limited to the first 4 h after sectioning, i.e., to the critical stage of cell activation, both the 55 and 100 mcg/ml caffeine concentrations were stimulatory. Under the same conditions 220 mcg/ml of caffeine delayed eyespot regeneration, while 11 mcg/ml was without effect. Constant exposure to caffeine in a concentration of 220 mcg/ml was particularly toxic to isolated heads, leading to complete disintegration of the eyespots and then of the entire head within 6-8 h. In about 40% of intact animals 200 mcg/ml of caffeine induced a reversible loss of one or both eyespots after 6-8 h of exposure. These observations were discussed in the light of cell activation mechanisms and photoreceptor susceptibility to methylxanthines.

Chemistry

A SYNTHETIC STUDY TOWARDS AN ETHYNYLATED AZASPIROCYCLIC INTERMEDIATE OF HISTRIONICOTOXIN. Benjamin Ayida and Godson C. Nwokogu, Dept. of Chemistry, Hampton University, Hampton, VA 23668. Histrionicotoxin (A:R_1 = *cis*-CH=CH-C≡CH; R_2 = *cis*-CH_2CH=CH-C≡CH), an alkaloid isolated from the skin secretion of the from Dendrobates histrionicus, blocks trans-synaptic ion transport. A number of methods for assembling the azaspirocyclic framework and for total synthesis of the natural compound, however, have been reported due to the difficulty of creating the unsaturated side-chains through multi-step C-C bond formations and functional group transformations. In order to overcome this difficulty, we wish to adopt a strategy that introduces the side chains in a convergent way as diynes which later could be stereoselectively reduced to cis-enynes. As a result, we have been studying different methods of generating butadiynes and 1,3-pentadiyne derivatives as well as searching for optimal conditions forPd(O)-catalyzed coupling of the butadiyne to model 2-bromoallyl acetates.



A

MULTINUCLEAR NMR INVESTIGATION INTO THE ACTIVATION OF SILICON-HYDROGEN BONDS BY A BINUCLEAR PLATINUM COMPLEX. Kimberly A. Brittingham and Serge Schreiner, Dept. of Chemistry, Randolph-Macon College, P. O. Box 5005, Ashland, VA 23005-5505. The secondary silanes, Me_2SiH_2, Et_2SiH_2, Ph_2SiH_2 and $MePhSiH_2$ react with the binuclear complex $[Pt_2(\mu\text{-}CO)(CO)_2(\mu\text{-}dppm)_2]$ (1; dppm = $Ph_2PCH_2PPh_2$) to give zerovalent μ-SiRR' complexes of the form $[Pt_2(\mu\text{-}SiRR')(CO)_2(\mu\text{-}dppm)_2]$ (R = R' = Me (2), Et (3), Ph (4); R = Me, R' = Ph (5)). In the reaction of 1 with Ph_2SiH_2 leading to 4, low temperature, multinuclear NMR data show that the reaction proceeds via an intermediate formulated as $[Pt_2(H)(SiHPh_2)(CO)_2(\mu\text{-}dppm)_2]$, 6.

BETWEEN TRUTH AND FICTION: WHAT DO YOU GET FROM THERMAL ANALYSIS? Lori Brock,* Jeff Keister* and Thomas C. DeVore, Dept of Chemistry, James Madison University, Harrisonburg, VA 22807. Several methods for extracting kinetic parameters from the thermal analysis data obtained for heterogeneous systems have been developed. Most use a best fit graphical method to determine intrinsic values for the kinetic parameters (A = pre-exponential factor, E_a = activation energy, and n = order of the reaction) and provide information about the reaction mechanism. However, Maciejewski has clearly shown that kinetic parameters determined depend on the experimental conditions used. No explanation for these differences was offered.
Evolved gas analysis - Fourier transform infrared spectroscopy (EGA - FTIR) provides additional information about heterogeneous processes. EGA - FTIR has been used to investigate the reaction between CCl_4 and V_2O_5 and the thermal decomposition of NH_4VO_3. The results of these investigations indicate that equilibrium processes, not kinetic processes, limit the "rate of reaction." These results offer possible explanation to the paradox presented by Maciejewski.

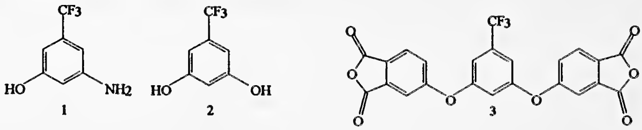
APPLICATIONS OF FLUORESCENCE TO BIOCHEMISTRY: INTERCALATION OF PROBES INTO DNA, Lisa Christianson and Benjamin A. DeGraff, Department of Chemistry, James Madison University, Harrisonburg, VA 22801. The intercalation of ethidium bromide into calf thymus DNA has been explored using various spectroscopic and fluorescent techniques. Shifts in peak positions and intensities were found in absorption and emission fluorescence spectra with addition of DNA. Emission polarization increased with addition of DNA in both buffer solutions and saturated sucrose solutions. Identical studies were performed using the ruthenium trisphenanthroline complex. The absorption spectrum of the solution diplayed little change upon addition of DNA, while the peak intensities were increased in the emission sprectrum. Quenching experiments were also performed, using the ruthenium trisphenanthroline complex as the intercalator and the ferrocyanide ion ($[Fe(CN)_6]^{4-}$) as the quencher. It was found that quenching of the $[Ru(phen)_3]^{2+}$ was minimized when it was intercalated into DNA, thereby protecting the metal complex from bulk solution environmental effects.

ESR STUDIES OF FREE RADICAL INTERMEDIATES IN THE ENZYMATIC OXIDATION OF SYRINGALDAZINE AND RELATED COMPOUNDS BY HORSE RADISH PEROXIDASE, Kelly A. Coggshall and Herbert J. Sipe, Jr., Department of Chemistry, Hampden-Sydney College, Hampden-Sydney, VA 23943. ESR spectra were observed for three methoxy *ortho* di-substituted phenols. Syringaldazine, acetosyringone, and syringaldehyde were studied in a system of H_2O_2/HRP to produce phenoxy free radicals. A well resolved spectrum was measured for the acetosyringone radical, hyperfine coupling constants assigned, and a simulation reproduced for the experimental spectrum. The ESR spectrum of the radical from the syringaldehyde system was not fully resolved, although hyperfine coupling constants were measured for methoxy substituents. The syringaldazine system produced radicals but the ESR spectrum was not intense and was incompletely resolved.

THE REACTION BETWEEN BIS(2,4-PENTANEDIONATO)LEAD(II) AND WATER VAPOR: A THERMODYNAMIC STUDY, Melissa A. Crouch and Thomas C. DeVore, Department of Chemistry, James Madison University, Harrisonburg, VA 22807. Evolved Gas Analysis-Fourier Transform Infrared Spectroscopy was used to investigate the reaction between bis(2,4-pentanedianato) lead(II) and water vapor from 300 to 600 K. 2,4 pentanedione, acetone, and carbon are the principle gaseous products produced. Powder X-ray diffraction indicated that lead oxide and lead metal were the principle solid products. The equilibrium concentrations of all products and reactants were determined as a function of temperature. This enabled the enthalpy of formation for bis(2,4-pentanedianato)lead to be estimated. The value determined is 855 $\pm$ 10 kJ/mol.

SYNTHESIS AND STUDIES OF $(\eta^5\text{-}C_5H_5)(CO)_xM(CH_2C_6H_3\text{-15-crown-5})$ Andrew Dattelbaum, Audra Wright, Donna S. Amenta and John A. Mosbo, Department of Chemistry, James Madison University, Harrisonburg, VA 22807. The purpose of this research was to synthesize, characterize and study the reactivity of transition metal complexes whose ligands contain crown ethers. One of the target molecules, $(\eta^5\text{-}C_5H_5)(CO)_2Fe(CH_2C_6H_3\text{-15-crown-5})$ (**1**), was prepared from $[(\eta^5\text{-}C_5H_5)(CO)_2Fe]^-$ and $ClCH_2C_6H_3$-15-crown-5 (**2**). The synthesis of **2** was accomplished from the reaction of 3,4-dihydroxybenzaldehyde with the dichloride of tetraethylene glycol, followed by $NaBH_4$ reduction of the resulting aldehyde to yield 4'-$HOCH_2$-benzo-15-crown-5. Treatment of this alcohol with thionyl chloride gave the desired **2**. All intermediate products have been characterized by NMR spectroscopy. The conversion of **1** into an acyl complex has been attempted using external phosphine ligands *via* carbonyl insertion reactions. The products from these attempts have been characterized by IR and NMR spectroscopy.

SYNTHESIS OF A NEW TRIFLUOROMETHYLATED DIANHYDRIDE FOR HIGH PERFORMANCE POLYIMIDES. Michael S. Hines and Roy F. Gratz, Dept. of Chemistry, Mary Washington College, Fredericksburg, VA 22401-5358. New synthetic routes have been developed for the preparation of 3-amino-5-hydroxybenzotrifluoride, 1, and 3,5-dihydroxybenzotrifluoride, 2. The syntheses begin with 3,5-dinitrobenzotrifluoride, which is converted first into a monobenzyl ether and then into a dibenzyl either by nucleophilic displacement of the nitro groups. Catalytic hydrogenations of the ethers lead to 1 and 2. Attempts to convert 2 into an arylene ether linked dianhydride, 3, by reaction with 4-fluorophthalic anhydride will be described.



1 2 3

COMPUTER SIMULATION OF PEPTIDE PROPERTIES. Tamaki Kurusu and David R. Bevan, Dept. of Biochemistry & Anaerobic Microbiology, Virginia Tech, Blacksburg, VA 24061-0308. It is generally accepted that lipophilic compounds diffuse through cell membranes more readily than hydrophilic compounds. However, diffusion requires desolvation of molecules prior to their passing through the lipid bilayer. We used the computer programs MOPAC, POLARIS, and AMSOL to simulate the solvation properties of a series of phenylalanyl peptide chains for which the permeability and lipophilicity were known experimentally. Our results clearly show that as the peptide length increases, the free energy of solvation (ΔG_{solv}) becomes more negative, suggesting that the free energy of desolvation (ΔG_{desolv}) is less favored and therefore the permeability decreases. Also, with increased methylation of backbone amide nitrogens, the ΔG_{solv} becomes less negative, favoring ΔG_{desolv}, and so increasing permeability. These results are consistent with experimental data obtained from the literature. Therefore, our computer simulations suggest that both ΔG_{solv} and lipophilicity of peptides must be considered when evaluating the permeability of bilayer membranes.

DEVELOPING A COMPUTER MODEL FOR SIMULATING THE CRYSTALLIZATION OF A MELT INTO A POLYCRYSTALLINE SOLID: OVERVIEW AND SOME GEOMETRIC PROBLEMS. Michael Leopold,* Dept. of Chem., Roddy V. Amenta, Dept. of Geol. and Geog., James Madison University, Harrisonburg, Va. 22807. Igneous rocks are naturally occurring polycrystalline solids that form the bulk of our planet. The fabric of an igneous rock, i.e. the spatial arrangements and chemical compositions of its crystals, contains the clues to its evolution over time by the slow cooling and crystallization of a melt. The inverse problem of interest to geochemists is determining what likely crystallization processes produced the resultant rock fabric. As with most inverse problems a unique solution model is rarely possible. Computer simulation of fabric development in polycrystalline solids would help in finding possible models for complex, non-linear, crystallization processes. The present study deals with one aspect of this problem, that of simulating the growth of crystals in a confined space and of resolving the competition for space among growing crystals in two dimensions. Specific efforts deal with methods for calculating and minimizing the overlap areas among adjacent crystals. Future efforts will deal rates of crystal nucleation and growth.

PYRIDINES IN FLAVORINGS AND FUELS: SYNTHETIC APPROACHES TO THE 2,5-DIALKYLPYRIDINES. David L. McElfresh and Wayne M. Stalick, Chemistry Department, George Mason University, Fairfax, VA 22030. 2,5-Dialkylpyridines occur widely in nature, from the essential oils of citrus fruits to the unrefined oil from oil shale and lower rank bituminous and lignite coals. The thrust of the current research is to find an efficient method for the synthesis of 2-methyl-5-alkylpyridines, 2-alkyl-5-methylpyridines and 2,5-dialkylpyridines, where the alkyl group would vary from five to fifteen carbon atoms. The original starting material was 2,5-lutidine, which upon reaction with sodium amide in ammonia give 5-methyl-2-pentylpryidine when reacted with 1-bromobutane. Dianion formation was assumed to be the ideal pathway into the 2-methyl-5-alkylpryidine series of compounds. Since the anion on the 5 position would form more slowly, it should react more readily such that with a limited amount of alkyl halide, substitution would preferentially occur at the 5 position. The use of excess $NaNH_2$ or KNH_2 in ammonia or LDA in THF resulted in alkylation or dialkylation on the 2 position only. New experiments have been performed using the "super base" system of potassium *t*-pentoxide and 1-ethylhexyllithium with 2,5-lutidine and with methyllithium, pentyl bromide and pyridine.

ANALYSIS OF THE SUBUNIT STRUCTURE OF THE GUANINE-7-METHYLTRANSFERASE. Joelle M. Onorato and Thomas O. Sitz, Dept. of Biochemistry and Anaerobic Microbiology, Virginia Tech, Blacksburg, VA 24061. Previous kinetic studies have defined three domains in the active site of the guanine-7-methyltransferase: S-adenosylmethionine domain, cap (GpppG) binding region, and the RNA binding domain. We have been successful in labeling (by UV cross-linking) the combined cap-RNA region of the enzyme with a ^{32}P-labeled capped RNA that was synthesized in vitro. Using native polyacrylamide gel electrophoresis we have characterized the size of the labeled protein as 107 K molecular weight and what appears to be a monomer of 55 K molecular weight. This agrees with earlier studies from this laboratory that characterized the subunit structure of purified enzyme as a homodimer with a molecular weight of 95 K (gel-exclusion chromatography) with a subunit molecular weight of 46 K (SDS-PAGE). Gel exclusion chromatography with HR-Sephacryl S-300 also showed a labeled enzyme with a molecular weight of 107 K. These data support our model for the subunit structure of the guanine-7-methyltransferase.

ESR SPECTROSCOPIC STUDIES OF THE ANTIOXIDANT PROPERTIES OF DIMETHYLTHIOUREA BY THE SPIN TRAPPING TECHNIQUE, Matthew T. Ranson and Herbert J. Sipe, Jr., Department of Chemistry, Hampden-Sydney College, Hampden-Sydney, VA 23943. Hydroxyl radical, formed by the Fenton reaction of hydrogen peroxide with Fe(II)-EDTA, is scavenged by dimethylthiourea. When the resulting radical species is spin trapped by 2-methyl-2-nitrosopropane (MNP), a single long-lived spin adduct is observed. The nitroxyl radical ESR spectrum consists of a triplet pattern (g-value ca. 2.00638 ± 0.00001) and is consistent with hydroxyl radical attack at the C of C=S with MNP trapping of the resulting $S^{\bullet}$ radical. Given the high reactivity of •OH, it is likely that other transient radicals are formed as well, but we do not observe them under our conditions.

AB INITIO MODELS OF METAL CHELATION SITES IN POLYIMIDES Donald D. Shillady, V. Kincaid and K. Esperdy, Virginia Commonwealth Univ., Dept. of Chemistry, Richmond, VA 23284-2006. It has been shown that Na^{+} ion enhances electrical conductivity in polyimides. Work in this laboratory by Guillem proved that Er^{3+} ions undergo ligand exchange and are chemically bound to typical polyimides by analyzing the magnetic circular dichroism (MCD) spectral changes in the hypersensitive bands. Recent work by Esperdy has shown that Ho^{3+} and Gd^{3+} will react with DuPont Pyre-mL to bind up to 8% (w/w) of total dry solid film using IR, MCD and UV spectroscopy. The question addressed here is how metal ions are chelated within amic-acid sites of an incompletely imidized polyimide. The GAMESS ab initio program has been used to optimize the geometry of an interesting new "tetradentate site" postulated to exist in polyamic acids and incompletely imidized polyimides. STO6G* (* = d orbitals on C, O, N) basis calculations are reported for the geometry and vibrational frequencies of a model compound, Aluminum N-phenyl phthalamate. Calculations show that such a tetradentate site could bind metal ions in Polyimides. The vibrational frequency analysis is compared with experimental IR data.

SYNTHESIS AND SPECTROSCOPIC CHARACTERIZATION OF METAL COMPLEXES OF BUCKMINSTERFULLERENE (C_{60}). Harvey E. Smith and Serge Schreiner, Dept. of Chemistry, Randolph-Macon College, P.O. Box 5005, Ashland, VA 23005-5505. Organometallic derivatives of C_{60} can be prepared by using dehydrochlorination of chloro hydrido transition metal complexes to generate coordinatively unsaturated metal fragments for subsequent reaction with C_{60}. The compound $[Pt(\eta^2\text{-}C_{60})(PPh_3)_2]$ has been prepared from $[Pt(H)(Cl)(PPh_3)_2]$ in refluxing ethanol/benzene in the presence of ethanolic NaOH and C_{60}. Elemental analysis and spectroscopic data of this compound are consistent with its previously reported preparation by reaction of $[Pt(\eta^2\text{-}C_2H_4)(PPh_3)_2$ with C_{60}. The new compound $[Ir(H)(CO)(\eta^2\text{-}C_{60})(PPh_3)_2]$ has been prepared in a similar fashion from $[Ir(H)_2(Cl)(CO)(PPh_3)_2]$ and has been characterized spectroscopically.

METHIONINE METABOLISM AND mRNA METHYLATION. Darrin R. Sorokti and Thomas O. Sitz, Dept. of Biochemistry and Anaerobic Microbiology, Virginia Tech, Blacksburg, VA 24061. Methionine is an important amino acid required for protein synthesis and the formation of S-adenosylmethionine (SAM). SAM is an important cellular methylating agent used to modify macromolecules such as protein and nucleic acids. We have been studying the methylation of mRNA cap structure, particularly the important guanine-7-methylation. By using the enzyme, guanine-7-methyltransferase isolated from Ehrlich ascites tumor cells, we can quantitate the amount of hypomethylation found in mRNA cap structure. We have been able to lower the level of methylation found in the cap structure of mRNA by restricting the level of methionine in the culture media of normal rat kidney (NRK) cells. Cycloleucine, an inhibitor of SAM synthetase, also was shown to have a similar effect. A combination of low methionine media and cycloleucine caused the greatest level of inhibition of cap methylation. Thus, by lowering the levels of cellular SAM, the guanine-7-methylation found in mRNA cap structure can be reduced.

CHARACTERIZATION OF A CYANOBACTERIAL GLOBIN. Marc V. Thorsteinsson and David R. Bevan, Dept. of Biochemistry & Anaerobic Microbiology, Virginia Tech, Blacksburg, VA 24061-0308. Potts et al. (*Science* 256, 1992), detected a globin, now known as cyanoglobin, in the nitrogen fixing cluster of the cyanobacterium *Nostoc commune* UTEX 584. Herein, we describe the large scale induction, purification, and partial structural characterization of recombinant cyanoglobin. Comparative studies using absorption spectroscopy and circular dichroism with sperm whale myoglobin and soybean leghemoglobin A reveal that cyanoglobin is atypical in its ability to bind exogenous ligands in the ferric form. The heme environment of cyanoglobin more closely resembles that of leghemoglobin A, although little sequence similarity exists. Cyanoglobin appears to possess a fast rate of autooxidation, which parallels the behavior of myoglobin isolated from *Tetrahymena caudatum*, with which it shares sequence similarities in the heme environment.

ESR SPECTROSCOPIC STUDIES OF THE REACTION OF NITRIC OXIDE WITH PHENOLIC ANTIOXIDANTS, Gresham T. Weatherly and Herbert J. Sipe, Jr., Department of Chemistry, Hampden-Sydney College, Hampden-Sydney, VA 23943. Nitric oxide (NO) has been reported to oxidize phenols and reversibly couple to the free radical produced. Since NO has recently been discovered to be an important biological messenger, its reaction with 2-*t*-butyl-4-methoxyphenol (BHA), a widely used food additive, was investigated to determine if NO would oxidize and reversibly couple to BHA. In order to optimize experimental parameters the BHA analog 3,5-di-*t*-butyl-4-hydroxyanisole (DTBHA) was also reacted with NO. NO was found to oxidize and reversibly couple to BHA and DTBHA. ESR hyperfine coupling constants taken from the literature could be used to simulate the BHA spectrum. However reported hyperfine coupling constants could not simulate the DTBHA spectrum. As yet the product of the reaction of NO with DTBHA is undetermined.

COMPUTATIONAL METHODS FOR COMPARING PREDICTED AND EXPERIMENTAL IR DATA. Robert H. Williams and Frank A. Palocsay, Department of Chemistry, James Madison University, Harrisonburg, Virginia 22807. A Visual Basic program has been written that enables the user to compare sample and predicted infrared spectroscopic data. Sample data is organized using Galactic Corporation's *Grams/386* while predicted spectroscopic data is created using Autodesk's *HyperChem*. Students construct molecules using *HyperChem* which then predicts the infrared spectrum of the molecule as drawn. The student next chooses a spectrum file saved by *Grams/386*. The peak heights and locations of the two data sets are then compared in a visual manner with both spectra displayed at the same time. The data sets can also be compared quantitatively by examining the tables of peak values. Easy to access on-line help has been added to aid the student's use of the program as well as improve the student's understanding of infrared spectroscopy.

THE SYNTHESIS OF ANALOGUES OF METHYL-*p*-HYDROXYPHENYLLACTATE (MeHPLA): POTENTIAL ANTIESTROGENIC AGENTS AND CANCER CELLS. R.L. Williams, Mark Elliott and K. Bryant, Enological Research Facility, Dept. of Chemistry/Biochemistry, Old Dominion University, Norfolk, VA 23529. Several analogues of the natural ligand MeHPLA found in normal and breast cancer cells have been synthesized in an attempt to generate potential antitumor agents for biological evaluation in human breast cancer cell in culture. MeHPLA was synthesized from commercially available *para*-hydroxyphenyllactic acid (HPLA) in 70% yield and characterized by IR and NMR analysis. MeHPLA was shown to exhibit a relatively high binding affinity for the type II estrogen binding sites in human breast cancer cell (MCF-7) in culture. Human breast cancer cells have been shown to produce a specific esterase which converts MeHPLA to the unreactive HPLA in vivo. In order to circumvent this phenomena, we have synthesized several nitrogen analogues of MeHPLA which should be resistant to this specific esterase and hopefully exhibit reasonable levels of type II binding affinity. The corresponding N-methyl analogue of MeHPLA has been evaluated and indeed does exhibit type II estrogen binding site affinity. The other compounds include the ethanol amine analogue and the benzyl analogue of MeHPLA. The synthesis and identification of these potential antitumor agents will be described in this paper.

ISOLATION AND CHARACTERIZATION OF PROCYANIDINS FROM GRAPE SEED EXTRACTS AND THEIR POTENTIAL BIOLOGICAL ACTIVITY. R.L. Williams, M. Elliott, J. Reddy and J. Recht, Old Dominion University Enological Facility, Dept. of Chemistry /Biochemistry, Old Dominion University, Norfolk, 23529. Crude grape seed extracts have been isolated from Virginia chardonnay grape seeds and the various bioflavanoids known as the procyanidin catechin, epicatechin, B1, B2, B3, and B4 have been separated and evaluated in various biological tests. Ten individual procyanidins have been isolated from the crude extract and identified by HPLC and TLC. These components of grape seed extracts have been tested in human fibroblast cells in culture with regard to their ability to affect cell growth. At reasonably high levels, several of the compounds apparently inhibit cell growth and are also effective in blocking cell damage due to high levels of free radicals produced *in situ* from a xanthine/xanthine oxidase study. These grape seed fractions as well as the crude seed extracts have now been shown to have some significant binding affinity to type II estradiol binding sites in MCF-7 human breast cancer cells in culture. The implications and significance of this latter study will be described in this paper as well as the methods of analysis of the separation of the various procyanidins.

SYNTHESIS AND CHARACTERIZATION OF LONG CHAIN ALKYLQUINOLINES. Nazdaneh Zahadat and Wayne M. Stalick, Chemistry Department, George Mason University, Fairfax, VA 22030. An important current goal in chemistry is to develop a better understanding of the decomposition pathways of alternate fuel sources such as oil shale and coal. A number of studies have been made demonstrating that studies of model compounds can give good extrapolations to the natural product. It has been estimated that nitrogen containing compounds constitute about 40% of the material found in crude shale oil and based on the GC/MS analysis of these compounds, long chain alkylquinolines along with alkylpyridines are the major constituents. In our continuing study of the pyrolyses of these compounds it became necessary to synthesize a series alkylquinolines. For this study, the isomeric undecylquinolines were selected. Considering that the pK_a's of methylquinolines are about 5 units lower than those of the corresponding picolines, it was assumed that the synthesis of these compounds, by the Brown and Murphey technique using sodium amide in liquid ammonia, would be an easy task. Even though the 2- and 4-methylquinolines easily underwent alkylation, 3-methylquinoline was resistant to alkylation because of side reactions. The previously unreported compounds synthesized in this study were characterized by NMR, IR, GC/MS and elemental analyses.

CARBON FIBER / POLYMER MATRIX ADHESION IN HIGH PERFORMANCE COMPOSITES. Hong Zhuang and J. P. Wightman, Dept. of Chemistry, Va. Polytechnic Inst. & State Univ., Blacksburg, VA 24061. There is increasing use of fiber / polymer matrix composites worldwide today, for example, in automobiles and in recreational equipment. Further, high performance composites are used increasingly in aircraft construction as in the new Boeing 777. The strength and toughness of composites is controlled by fiber / matrix interfacial adhesion. The purpose of this work is to relate the measurements of fiber / matrix adhesion to properties of the carbon fiber and the polymer matrix. Single fiber fragmentation tests were carried out to evaluate the strength and temperature dependence of interfacial adhesion between carbon fibers and epoxy resins. The results were correlated with the carbon fiber surface properties. The surface composition of the fibers was determined by XPS (x-ray photoelectron spectroscopy), the fiber topography by SEM (Scanning electron microscopy) and fiber surface energy by DCAA (dynamic contact angle analysis). Increasing the surface energy of the carbon fiber by surface pretreatment increased the calculated interfacial shear strength. (Supported by McDonnell Douglas Aerospace)

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Vol. 45 No. 4 WINTER, 1994

TABLE OF CONTENTS PAGE

Virginia Journal of Science
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Factors Determining Distribution and Abundance of Delmarva Grass Shrimp (*Palaemonetes* spp.)

Robert E. Knowlton [1], **Ritindra N. Khan** [2], **Paul M. Arguin** [3], **Tayseer A. Aldaghlas**, and **Rabindra Sivapathasundram**, Department of Biological Sciences, George Washington University, Washington, DC 20052

ABSTRACT

Samples of grass shrimp were collected bimonthly at five stations, each with two sites: (A) wooden pilings (marina) and (B) mud/sand/shell flats. Populations, especially of *Palaemonetes vulgaris*, were least abundant during colder months, most numerous in September. Relative to *Palaemonetes pugio*, *P. vulgaris* abundance decreased with decreasing average salinity (30 to 15 ppt), to near zero at 12 ppt. At polyhaline stations *P. vulgaris* was significantly more abundant at "A," *P. pugio* at "B," sites. In an aquarium on a homogeneous substrate (sand), both species, alone and mixed together, usually exhibited a random distribution pattern. On four different substrates (arrayed in 32 cubicles), most animals settled on wood (37% of all observations) and mud (36%); few on shell (15%) and sand (12%). At 20 (vs. 40) ppt significantly more shrimp were observed on mud. More *P. pugio* selected mud, and more *P. vulgaris* wood, than any other substrate. The most significant differences in mixed (vs. single) species distributions occurred among *P. vulgaris* (increase on wood, decrease on mud). It is concluded that salinity and perhaps temperature influence spatial distribution and abundance of these species and, where sympatric, differential substrate selection and interference competition are important aspects of resource partitioning.

INTRODUCTION

Decapod Crustacea of the genus *Palaemonetes* are predominant members of shallow-water benthic communities in Atlantic and Gulf coast estuaries (Wood, 1967; Nixon and Oviatt, 1973; Heck and Orth, 1980; Anderson, 1985). "Grass shrimp" are of great ecological importance because of their position as opportunistic omnivores in estuarine food webs (Odum and Heald, 1972; Welsh, 1975; Morgan, 1980; Nelson, 1981; Chambers, 1981, 1982; Kneib, 1985; Posey and Hines, 1991; Uguccioni and Posey, 1992), and they are of some economic value in the fishing industry as bait. The most common species along ocean and bay shores of the "Delmarva" peninsula are *P. pugio* Holthuis and *P. vulgaris* (Say). Their distribution throughout this area, though, is not uniform. At some estuarine sites they coexist whereas at other places only one of the species occurs (Williams, 1984).

Salinity is thought to be a significant factor in controlling distributions of grass

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shrimp populations, inasmuch as *P. pugio* can be found from tidal fresh water to the ocean, while *P. vulgaris* exhibits a more restricted distribution (15-35 ppt) along the salinity gradient (Knowlton and Williams, 1970). Different salinity tolerances of the two species (Bowler and Seidenberg, 1971; Thorp and Hoss, 1975; Knowlton and Kirby, 1984; Knowlton and Schoen, 1984) could account, at least in part, for this distribution pattern. Thorp and Hoss (1975) compared temperature tolerances, concluding that winter temperatures do not affect habitat partitioning in these species. Since grass shrimp are demersal, characteristics of the substrate may also be an important factor. Chambers (1982) noted that *P. pugio* was abundant in muddy-bottomed creeks of high areas of Great Sippewisset (Massachusetts) marsh whereas *P. vulgaris* was predominant in "sandy" low-marsh creeks. Thorp (1976) studied relative abundances of the two species at sites of different substrate composition in the Newport River (North Carolina) estuary, and he discerned distribution patterns of each species, with or without the other species present, in an aquarium divided into mud and shell-mud substrate sections. In pilot studies conducted by Arguin et al. (1989), species differences in substrate selection patterns were exhibited when individuals of one or both species were introduced into an aquarium provided with four different substrates (mud, sand, shell, wood), but their results were based on only a few trials and one observation time per trial. Finally, Thorp (1976) provided evidence that interspecific competition may be important. Although he did not observe behavioral interactions, he found that *P. vulgaris* was able to displace *P. pugio* physically from a "preferred shell substratum," i.e., one that provided protection from predation. Chambers (1981, 1982) found that *P. vulgaris* seemed to dominate *P. pugio* in one-on-one same-sex interactions.

The main purpose of the present study, which had both field and experimental components, was to define the extent to which salinity and substrate, and presence/absence of the other species, affect the abundance and spatial distribution of these two species of grass shrimp. Populations of *Palaemonetes* spp. were sampled throughout the "Eastern Shore" region of Virginia, Maryland, and Delaware, at which time substrate observations, salinity readings, and other measurements were undertaken. In the laboratory, trials were run under controlled conditions to determine (1) dispersal patterns of each species (on a homogeneous substrate), (2) substrate preferences, (3) the influence of salinity on substrate selection, and (4) the extent to which the two species interact in relation to substrate choice.

MATERIALS AND METHODS

Field Studies

Bimonthly collections of *Palaemonetes* spp. were made during 1987 at five shoreline stations on the Delmarva peninsula selected mainly because they cover a wide range of salinity conditions (circa 12-30 ppt). On the ocean side stations were located at (1) Indian River Bay on Burton Island, Del.; and (2) Chincoteague Bay, Chincoteague, Va. In Chesapeake Bay stations were situated at (3) Kings Creek, Cape Charles, Va.; (4) Robin Hood Bay, near Saxis, Va.; and (5) Mezick Pond, Sandy Point State Park, near Annapolis, Md. Each station included two study sites:

(A) a marina consisting of wooden pilings, buttresses, docks, etc., with attendant algae and epifauna (e.g., barnacles, tunicates, sponges) and (B) nearby flats of sand, mud, oyster shells (or some combination) bordered by marsh vegetation (*Spartina alterniflora* at Stations 1-4, *Phragmites australis* at Station 5) and bare peat. At each station, collections were timed so that they would be accomplished at about the same time of day and stage of tide (about 2 hours prior to low tide). At each "A" and "B" site, salinity was measured with a refractometer, water and air temperatures with an ordinary pocket thermometer. The amount of oxygen dissolved in the water (sample collected in BOD bottle) at each site was determined by means of the "azide modification" (Hach Chemical Co.) of the Winkler method. Animals were collected using a long-handled Ward's "D-frame" (30 cm along straight edge, 30 cm deep) aquatic dip net dragged in a consistent manner (each time a linear haul of about 1 m) over a given area, so as to obtain crude estimates (average no./haul) of shrimp abundance. Collecting effort at each station was about 1 man-hour, but sampling was stopped earlier when approximately 300 animals were obtained. Captured animals making up each site sample were preserved in 95% ethanol. Later, the individuals in a sample were sorted and tallied according to species. The two species were differentiated on the basis of rostrum structure and other diagnostic features (as noted in Holthuis, 1952). Differences in numbers of each species between sites were analyzed using the Chi-square (X^2) test, while Pearson's product-moment correlation coefficient (rho) was calculated to test for the magnitude of correlation between percent *P. pugio* found at each site and each of the measured abiotic parameters (Glantz, 1987).

In October of 1989, additional samples of shrimp were collected from different areas of Station 3, where different substrates could be clearly demarcated. One such sample was taken from wooden pilings ("A" site), and one each from three areas (within site "B"): a flat composed of mud (13% sand, 41% silt, 46% clay), an oyster bar over sand, and bare sand. Again, the number of individuals of each species was determined for each sample.

Laboratory Experiments

Living shrimp of both species, sea water, and substrate samples were also collected from Station 1 (both sites), for utilization in the experimental part of the study, viz., tests designed to assess (1) distribution of individuals of one or the other species in an aquarium on a homogeneous substrate (sand), and (2) distribution of single-species populations, or the two species mixed together, at one of two levels of salinity, over an array of four different substrates (mud, sand, shell, and wood). Collections were made in the spring of 1990 and 1991, always around 1330 hr, under the following average conditions: 15 °C water temperature, 31 ppt salinity, 10.7 ppm dissolved oxygen. Prior to testing, collected animals were kept for about a week in "stock" aquaria containing a mixture of artificial (Instant Ocean® sea salts dissolved in deionized water) and collected sea water adjusted to 30 ppt salinity, and a small amount of gravel, in an attempt to reduce any field-derived acclimation that might have occurred and to allow the animals time to adjust to laboratory conditions. Stock tanks were exposed to natural daylight but all tests were carried out in a windowless room with a fluorescent ceiling light kept on throughout each test run.

In a preliminary experiment designed to determine whether or not individuals

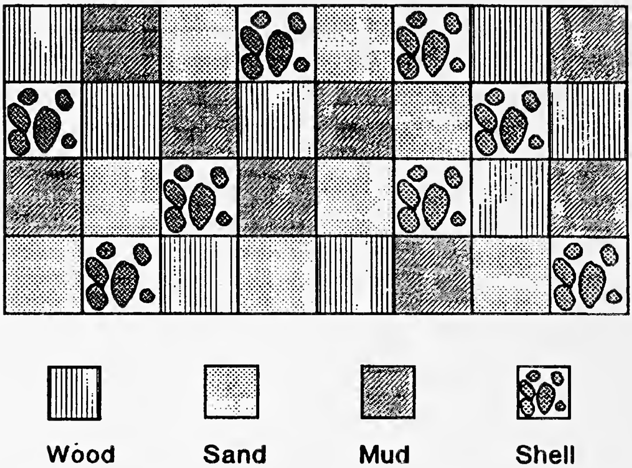

FIGURE 1. Diagram of aquarium grid (top view) in "heterogeneous substrates" experiment, showing arrangement of cubicles, each containing the substrate indicated.

of each species distribute themselves randomly on a homogeneous substrate, sand was added to a 60 x 30 x 30 cm aquarium divided at the bottom into a "grid" of 32 cubicles (each one about 50 cm^2) by partitions made from clear acrylic plastic, with their upper edges situated about 1 cm above the substrate surface. Fifty individuals of a species were placed in the tank and allowed to distribute themselves until the following morning, at which time their location within the tank was noted. This procedure was done with each species separately and repeated once. Frequencies of occurrence of animals in the cubicles were then compared, using Chi-square, with expected frequencies in a Poisson distribution (Sokal and Rohlf, 1981). In a satellite study this analysis was extended to include additional runs using individuals of one or the other species, or both in equal numbers, and at a particular density (50, 100, 150, or 200 animals per tank). In each run, the number of animals in each cubicle was noted 15 times over 3 days.

The main experiment, consisting of three types of trials, was carried out using an aquarium in which each cubicle was "filled" with one of four substrates: sand, oyster shell (whole and broken), mud (1-cm layer over an understory of sand, to reduce turbidity), and wood (flat piece of driftwood lacking macroscopic epifauna, resoaked in sea water for one week, cut into squares to fit the cubicles and held underwater by a zinc weight attached to the underside by silicone caulking and coated with plastic marine varnish). The cubicles were arranged in such a way that the same substrates were never adjacent (Fig. 1), with each corner of the aquarium containing a different substrate (to equalize any "corner effects"). This heterogeneous substrate was not quite flat, with cubicle edges, shell, and the wooden blocks projecting 1-2 cm above the sand/mud surface. In each run of each trial, at noon animals were added to the aquarium, which was filled about halfway with an artificial-natural salt water mixture made up to the desired salinity. The number of animals in each of the 32 cubicles was noted at 3-hr intervals (± 30 min) until midnight, and at 0900 hr the next morning, to check for any diel differences in distribution patterns. At 0900 hr the tank was rotated 180°, to compensate for

any directional influences (e. g., ceiling light) within the room that might be attracting the animals, and six more observations of animal distribution were made during the second day as well (at 1200, 1500, 1800, 2100, 0000, 0900 hr). Only individuals clearly positioned on one of the substrates were tallied (i.e., swimming animals and those situated on a partition or along the aquarium side were not included). Two aquaria were used in each run, one containing water of 20 ppt salinity, the other with 40 ppt water. The tanks were placed side by side on a counter, separated by a distance of about 1 m; each run was repeated with the tanks in reversed positions. Two days prior to each test, animals to be tested at 20 ppt were brought out of the "stock" aquarium (where salinity = 30 ppt) and added to water of 25 ppt, then 20 ppt the next day. Another group of animals was acclimated to 40 ppt in the same two-step fashion. Salinity and temperature readings were taken every time the shrimp populations were observed; respective means ±standard deviations ($n = 72$) are 20.2 ± 1.1 ppt and 20.1 ± 1.7 °C, 39.7± 1.2 ppt and 20.3 ± 1.6 °C. The water in each tank was aerated by a single pump connected by tubing to an airstone positioned roughly in the middle, but the pump was turned off at least half an hour prior to an observation time because it was thought that the animals might be attracted to the bubbling air. Dissolved oxygen, checked prior to and during a run, was found to be above a level (4 ppm) that is well tolerated by both species (Welsh, 1975). The level of zinc in the test water did not exceed 45 ppb, comparable to levels found in many coastal waters (Bryan, 1976). The number of animals per tank to be used in each trial (60) was determined on the basis of results (see below) from the satellite study, i. e., a density that would be large enough to yield sufficient data but one that would not be likely to produce a non-random dispersion pattern and/or induce the animals to move around, thereby making counting difficult.

In the first trial type, 60 individual *P. pugio* were placed into each of the two aquaria and their locations noted, as described above. Then, a second trial was conducted in the same way, using *P. vulgaris* only. A third type of trial consisted of placing 30 members of each species simultaneously into the aquaria and subsequently noting the distributions of both species. In order to be able to differentiate the two species easily while they were both in the tank, individual *P. pugio* were dyed beforehand using a solution of Alcian blue, a process used by Coen et al. (1981) and determined by them not to affect the behavior and survivability of the shrimp. All three trials were repeated once; in the second run of the "mixed species" trial, individuals of *P. vulgaris* were dyed. In summary, the design of this experiment resulted in a total of 768 observations (i. e., number of shrimp on one of the four substrates) in the data set, or: 2 species x 2 "conditions" (i. e., single species, two species mixed together) x 2 salinities x 4 substrates x 2 days x 6 times (of each day) x 2 runs. Statistical analysis included a four-way analysis of variance (ANOVA) of the arcsine-transformed data, using a general linear models procedure (SAS Institute, 1985) with species, condition, salinity, and substrate as the main effects. Means of the factors were examined using Tukey's just significant difference (JSD) and graphical construction of confidence intervals (CI) about the means using the formula JSCI = mean ± JSD/2 (Sokal and Rohlf, 1981). In all analyses a probability (P) of less than 0.05 was required for significance.

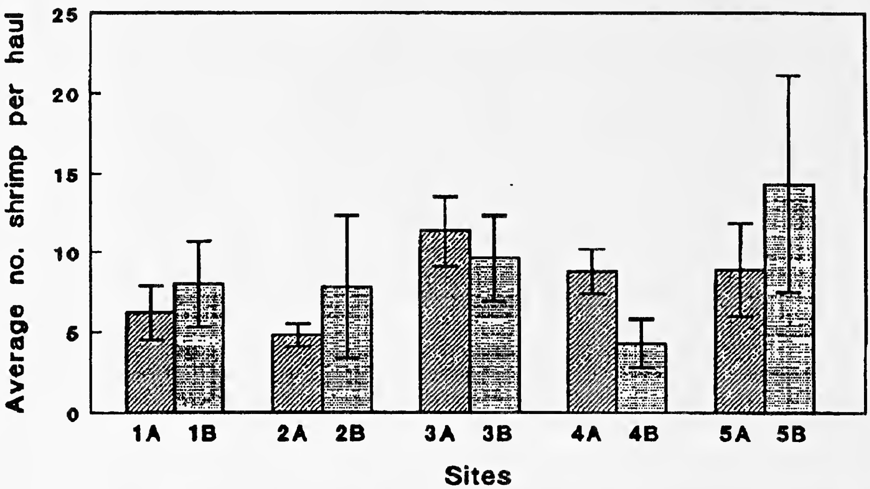

FIGURE 2. Mean abundance (approximate no. per haul of dip net) of *Palaemonetes* individuals (both species) at each collecting site (summed over the 6 months). Each vertical bar indicates standard error of the mean.

RESULTS

Abundance and Distribution in the Field

Of the 9,293 grass shrimp collected bimonthly from the five stations, nearly all were *Palaemonetes pugio* (68%) or *P. vulgaris* (32%). A third species, *P. intermedius*, was found in May (3 individuals at Sta. 2B) and July (1 animal, Sta. 5B); these animals, along with 7 juveniles (taken from Sta. 3A in September) of uncertain identity, were excluded from "species composition" calculations.

Figure 2 portrays average number of individual *Palaemonetes* (regardless of species) per haul (of the dip net) at each of the ten collecting sites (all months combined). A given haul yielded anywhere from zero to over 100 animals, but typically (i.e., 85% of the time) the yield in a haul ranged between 1 and 15. Maximum abundance was exhibited at Station 5B, where in May an average haul contained about 40 animals. Failure to collect any shrimp occurred on only one occasion – at Station 4B in January. Stations 4B and 2A were, on average, least productive, possibly because these sites are not as well protected from wave action and currents. The difference in means between all A and B sites (8.0 and 8.8 animals/haul, respectively) is not significant ($t = 0.407$ with $df = 58$; $P = 0.686$).

The same abundance data are presented by month (all stations combined), to illustrate seasonal variation (Fig. 3). During the winter months (January and March) animals were consistently less abundant, except at the A sites of the southern stations (3 and 4) of Chesapeake Bay. More animals appeared in May hauls, with 19% of *P. pugio* (but only a single *P. vulgaris* at Sta. 3) females bearing eggs. July samples contained numerous ovigerous females of both species and, at Stations 3 and 5, some juveniles. The highest numbers occurred in September, at which time populations contained year-old adults plus juveniles at all stations. (See Ganz and Knowlton, 1992, for an assessment of reproductive characteristics of these populations.)

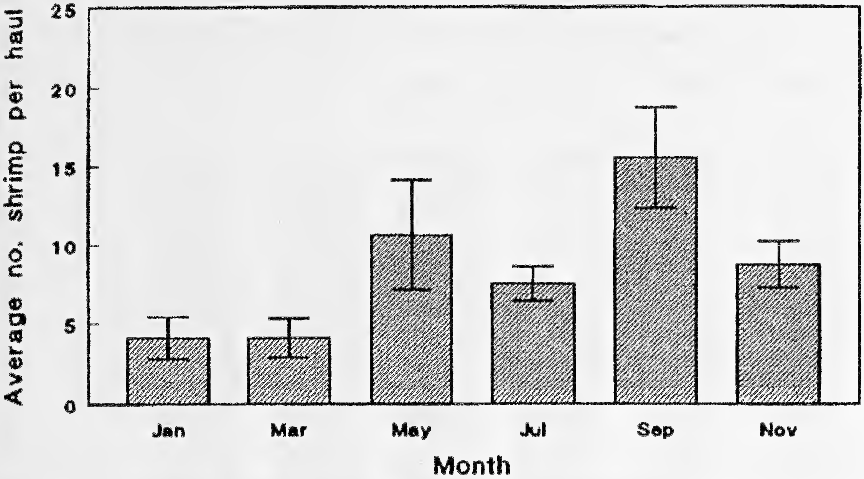

FIGURE 3. Mean number (per haul of dip net) of *Palaemonetes* individuals (both species) collected according to month (summed over the 10 sites). Each vertical bar indicates standard error of the mean.

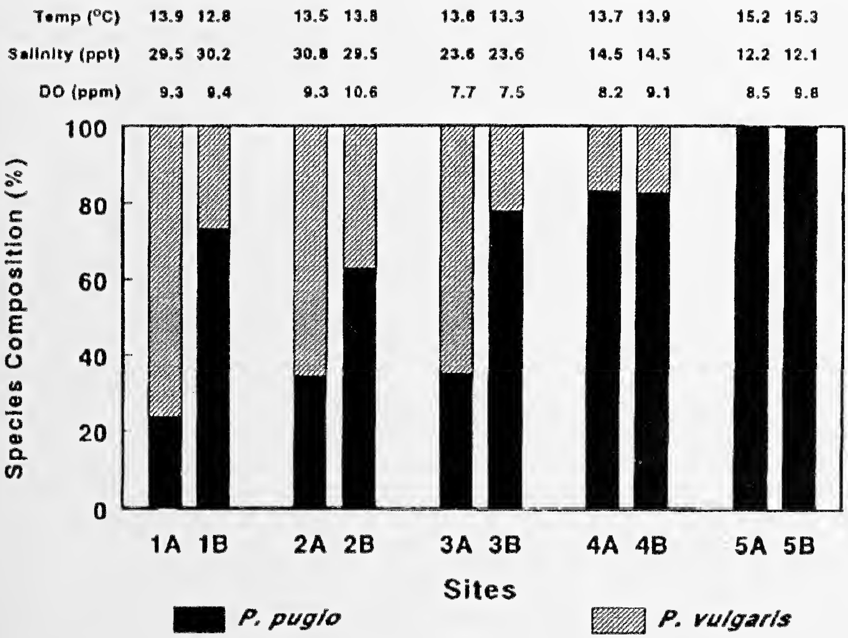

FIGURE 4. Species composition (mean % of *Palaemonetes pugio*) in samples collected at each site (summed over months), with average temperature, salinity, and dissolved oxygen (DO) levels measured. Percent *Palaemonetes vulgaris* = 100 - (% *P. pugio*), other and unknown species of *Palaemonetes* not being included in the total.

As shown in Fig. 4, which portrays average % of *P. pugio* collected over the year at the ten field sites, this species was more abundant than *P. vulgaris* at both A and B sites of Stations 4 and 5, where average salinities were less than 15 ppt; only one

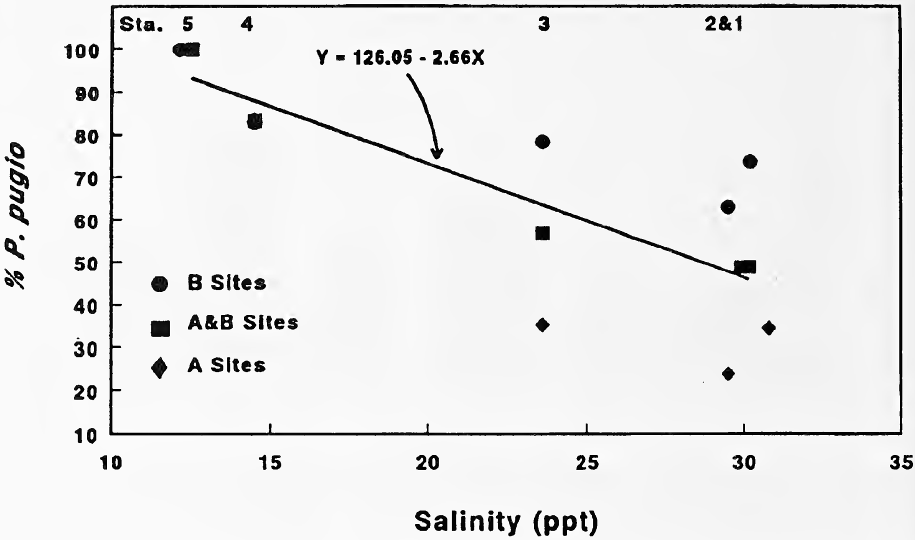

FIGURE 5. Mean % of *Palaemonetes pugio* in samples collected at each site (summed over months) in relation to mean salinity measured at each site and averaged over the year. Percent *Palaemonetes vulgaris* = 100 - (% *P. pugio*). Regression line is fitted to pooled (A & B sites) data.

P. vulgaris, a juvenile, was found at Station 5 (5B, September). At stations (1-3) where salinities were generally above 20 ppt, *P. vulgaris* dominated at A sites, *P. pugio* at B sites. The Chi-square test showed that differences in number of individuals of each species between the two sites were significant at Stations 1 (X^2 = 361.614 with df = 1; P < 0.001), 2 (X^2 = 92.845, P < 0.001), and 3 (X^2 = 321.108, P < 0.001), but not 4 (X^2 = 0.003, P = 0.959). Differences between only three sample pairs (Sta. 3, Jan.; Sta. 2, Mar.; Sta. 1, May) were not significant.

Figure 5 depicts average % *P. pugio* collected (all months) at the sites as a function of average salinity, to illustrate a linear relationship of species composition with this environmental parameter. As measured by Pearson's correlation coefficient (r) the negative correlation (r = -0.768) between % *P. pugio* and salinity is highly significant (t = 3.391 with df = 8; P = 0.009). When A and B sites are considered independently the relationship is even stronger (for A sites: r = -0.954, t = 5.502 with df = 3, P = 0.012; for B sites: r = -0.884, t = 3.270, P = 0.047). The slopes of the regression lines (-3.81 for A site data, -1.43 for B) are significantly different (calculated t = 2.908; critical value of t = 2.447 at df = 6, P = 0.05). The higher proportion of *P. pugio* (vs. *P. vulgaris*) at B (vs. A) sites of the polyhaline stations (1-3) is also seen in Fig. 5. A slight positive correlation (r = 0.488) between % *P. pugio* and temperature (A and B sites combined) was discerned but was found to be not significant (t = 1.582; P = 0.152). Virtually no correlation (r = -0.015) between *P. pugio* abundance and dissolved oxygen was exhibited (t = 0.043; P = 0.967).

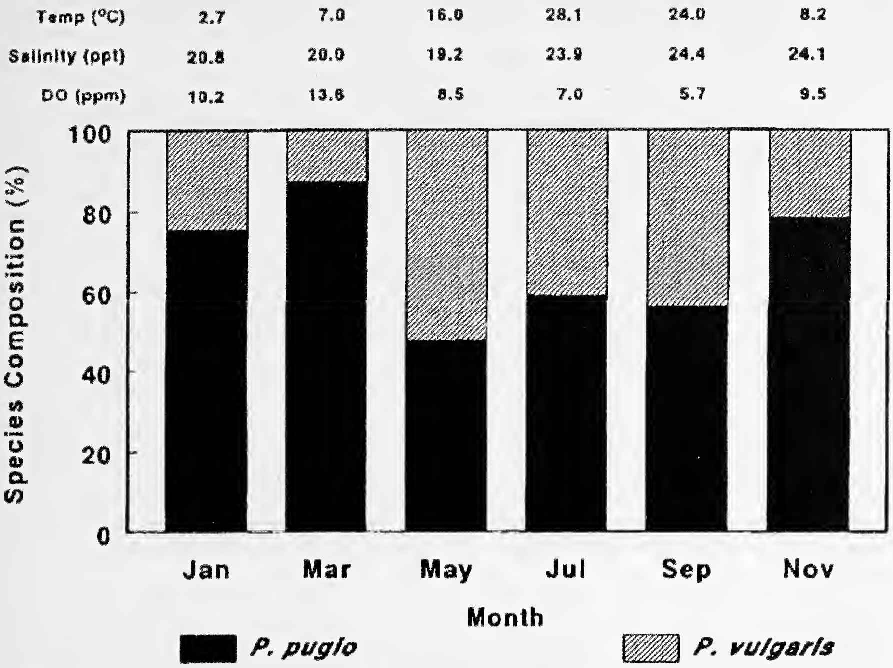

FIGURE 6. Species composition (mean % of *Palaemonetes pugio*) in samples collected each month (summed over sites), with average temperature, salinity, and dissolved oxygen (DO) levels measured. Percent *Palaemonetes vulgaris* = 100 - (% *P. pugio*).

In Fig. 6 average % *P. pugio* collected at all sites during a particular month is indicated. It can be seen that relative abundance of each species was around 50% during the late spring and summer, and that *P. pugio* was proportionately more abundant (> 75%) during the colder months (Nov.-Mar.), when measured salinities were also lower (especially Jan.-Mar.) and oxygen readings higher. The correlation between % *P. pugio* and temperature is fairly strong ($r = -0.725$) but not statistically significant ($t = 2.107$ with $df = 4$; $P = 0.103$). The relationship with salinity is very weak ($r = -0.074$) and not significant ($t = 0.148$; $P = 0.890$). However, the correlation with dissolved oxygen is high ($r = 0.806$) and significant at $P = 0.053$ ($t = 2.724$).

Samples taken at four specific areas of Station 3, where substrate differences could be clearly discerned, differed with regard to relative abundance of the two species. On wood, *P. vulgaris* was more numerous (75.3% of individuals in sample) than *P. pugio* (24.7%), while *P. pugio* dominated in samples taken from shell (93.3%), sand (98.0%), and mud (100%).

Distributions Under Laboratory Conditions

Results from the preliminary "homogeneous substrate" experiment are shown in Table 1. These data (two runs combined) demonstrate a random distribution pattern of individuals of each species (separately, at a density of 50 per aquarium) because frequencies of occurrence (of animals in the cubicles) display little deviation from a Poisson series (that gives the frequency with which groups of 0, 1, 2,...

TABLE 1. Actual number of cubicles in aquarium grid (frequency) occupied by a given density of individuals* (no. individuals per cubicle) compared with theoretical number (expected frequency) reflecting a random distribution over a homogeneous substrate (sand).

No. individuals per cubicle	*Palaemonetes pugio* Frequency	*Palaemonetes pugio* Expected frequency	*Palaemonetes vulgaris* Frequency	*Palaemonetes vulgaris* Expected frequency
0	11	14.97	13	16.18
1	22	21.75	25	22.25
2	22	15.80	16	15.30
3	9	7.65	9	7.01
4	0	2.78	1	2.41

*In each run, 50 individuals of one or the other species were added to an aquarium with a 32-cubicle grid, but data were obtained from two runs for each species separately. Thus, the sum of (cubicle) frequencies = 64, as data from each run are pooled. The sum of the products (frequency x no. individuals per cubicle) is slightly less than 100 because a few animals were situated off the bottom when counted.

will be encountered if distribution is random). Calculated X^2 for *P. pugio* was 3.684, for *P. vulgaris* $X^2 = 1.033$ (critical value of $X^2 = 5.991$ at df = 2, P = 0.05). In the satellite study, it was found that distributions were generally random as long as shrimp densities did not exceed 100 per tank. Specifically, *P. pugio* distributions were random 80% of the time (n = 30), *P. vulgaris* 77%, under these conditions. At densities of 150 and 200 animals per tank, random distributions resulted only 10% and 7% of the time, respectively. Data from the mixed-species runs were similar, except that non-random patterns occurred about 50% of the time when 150 animals (75 of each species) or 200 animals were tested. Also, at the higher densities counts often exceeded 100% of the actual number of animals put into the tank, indicating that the animals were moving about more and that the same animal was occasionally being counted again. For these reasons, the main experiment was conducted using 60 animals per tank in each run.

In the "heterogeneous substrates" (main) experiment, the animals demonstrated decided substrate preferences. Considering all observations (i. e., in both runs regardless of conditions), 37 ± 3% (mean ± standard error) of all animals were seen on wood, 36 ± 4% on mud, 15 ± 2% on shell, and 12 ± 2% on sand. The data for the two runs are the same except for a 5% difference in animals on sand and a 4% difference in those on wood. Means analysis of data sorted according to time of day indicated that there was no significant diel variation in this pattern.

Results of the four-way ANOVA of the arcsine-transformed data (Table 2) show that neither interaction of the four factors (species x condition x salinity x substrate) nor any three-way interaction involving salinity was significant. However, highly significant differences in substrate selection were exhibited by the two species alone and both species mixed together (species x condition x substrate; Table 2). Also, a two-factor interaction between salinity and substrate was deter-

TABLE 2. Results of four-way analysis of variance performed on arcsine-transformed percentages of experimental populations of shrimp associated with one of four different substrates in an aquarium grid (Fig. 1).

Source of variation	Degrees of freedom	Mean square	F value	P > F
Model				
Species	1	0.0000	0.00	0.9872
Condition	1	0.0012	0.14	0.7108
Salinity	1	0.0001	0.01	0.9303
Substrate	3	3.8306	437.38	0
Species x condition	1	0.0009	0.11	0.7425
Species x salinity	1	0.0001	0.02	0.8992
Species x substrate	3	1.1018	125.81	0.0001
Condition x salinity	1	0.0001	0.01	0.9363
Condition x substrate	3	0.2901	33.13	0.0001
Salinity x substrate	3	0.2342	14.09	0.0001
Species x condition x salinity	1	0.0000	0.00	0.9692
Species x condition x substrate	3	0.0606	6.92	0.0001
Species x salinity x substrate	3	0.0127	1.44	0.2285
Condition x salinity x substrate	3	0.0111	1.27	0.2825
Species x cond. x sal. x subst.	3	0.0155	1.77	0.1523
Error	736	0.0088	–	–

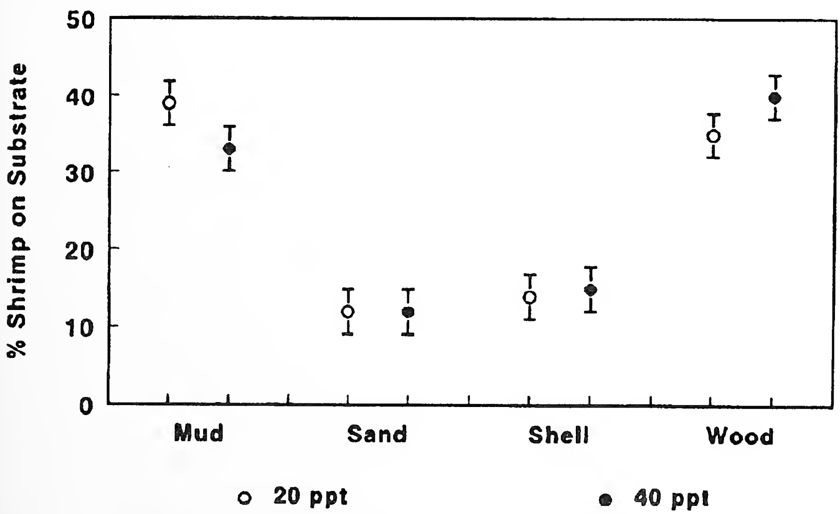

FIGURE 7. Mean % of individuals (n = 96) observed on each of four substrates grouped according to salinity level, regardless of species or "condition" (alone/mixed). Each vertical bar indicates confidence interval (JSCI) about the mean. Substrates were distributed in aquarium according to the pattern shown in Figure 1.

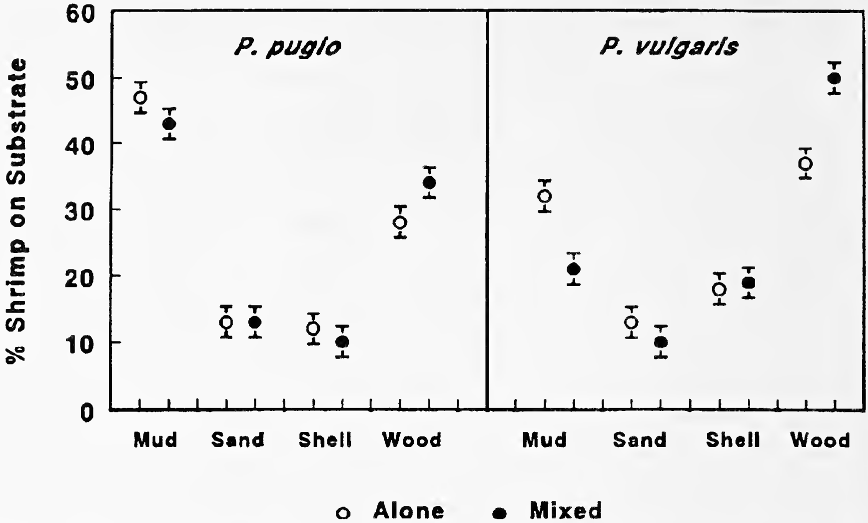

FIGURE 8. Mean % of individuals (n = 48) observed on each of four substrates grouped according to species and "condition" (the species "alone" or both species "mixed" in equal numbers), regardless of salinity level. Each vertical bar indicates confidence interval (JSCI) about the mean. See Fig. 1 for distribution pattern of substrates in aquarium.

mined to be highly significant, indicating that substrate selection of the two species (considered collectively) is influenced by salinity.

Salinity effects on substrate selection are depicted in Fig. 7. The number of animals (both species considered collectively) on sand and shell was seen to be about the same at both salinity levels, but at 20 ppt significantly more were observed on mud. At 40 ppt more animals occurred on wood than at 20 ppt, but the difference is not statistically significant.

The nature of the differences not related to salinity is illustrated in Fig. 8, which shows distributions (data from both salinity conditions pooled) of individuals grouped by species and condition. Proportionately more *P. pugio* selected mud, and more *P. vulgaris* selected wood, than any other substrate whether the other species was absent or present. Presence of *P. pugio* resulted in a highly significant increase in average number of *P. vulgaris* on wood and a highly significant decrease in the number on mud. A "shift" from mud to wood by *P. pugio* in the presence of *P. vulgaris* also occurred, but it was of lesser magnitude, the increase in number of *P. pugio* on wood being significant, the decrease in number on mud not so. Both species were considerably less numerous on shell and sand (vs. mud and wood). *Palaemonetes pugio* appeared on these substrates in about equal numbers, while *P. vulgaris* was significantly more common on shell. Numbers of one species on sand and shell did not differ radically in the presence of the other. Because effects of species, condition, and substrate are tied significantly together, neither the two-way effects involving any of these factors nor the independent effect of each of them can be assessed.

DISCUSSION

In the present study, abundance of both species was found to be greatest in September – the result of an influx of juveniles recruited from eggs hatched throughout the reproductive period (April-September). Similarly, peak densities of *P. pugio*, especially juveniles, in late summer-fall have been noted in populations inhabiting Bissel Cove, Rhode Island (Nixon and Oviatt, 1973; Welsh, 1975), North Inlet estuary, South Carolina (Sikora, 1977), Sapelo Island, Georgia (Kneib, 1987), and Galveston Bay, Texas (Wood, 1967). On the other hand, trawling in eelgrass (*Zostera*) meadows of 1-2 m depth in lower Chesapeake Bay, Heck and Orth (1980) collected maximum numbers of newly recruited *Palaemonetes*, mostly *P. vulgaris*, in June. With onset of winter, both species were seen to be less abundant (Fig. 3), *P. vulgaris* moreso than *P. pugio* (Fig. 6), especially at the northerly oceanside stations (1 and 2) and all the shallower marshy (B) sites. While this result may be due to greater difficulties inherent in winter sampling (ice, etc.), and while the observed negative correlations between %*P. pugio* and salinity/temperature do not necessarily indicate cause and effect, it might be inferred that, in response to low temperature and low salinity of late winter and early spring, *P. vulgaris* populations tend to migrate toward the south to deeper, warmer, more saline offshore waters, whereas *P. pugio* is more likely to remain inshore (perhaps even moving in to habitats vacated by *P. vulgaris*). Thorp and Hoss (1975) found that both species are quite tolerant of low temperature and rapid decreases (e. g., 10 to 2 ^{o}C); nevertheless Thorp (1976) observed a marked wintertime decrease in *P. vulgaris* abundance (relative to *P. pugio*) in two shelly areas at the mouth of the Newport River estuary. Chambers (1982) also noted a paucity of *P. vulgaris* during the winter months. In addition, Thorp's observation of greater numbers of *P. vulgaris* occupying cages in lower tidal zones, where temperature variations are less pronounced, indicates that this parameter may be a significant determinant of spatial distribution.

Results of the station and site analysis (Fig. 4) demonstrate that in the field *P. vulgaris* is more numerous at the marina (A) sites, in which wooden structures dominate, but only if the salinities are above 20 ppt. On the other hand, *P. pugio* is more evident on the "flat" marshy substrates (sand, mud, shell, peat, etc.) of the B sites and at low salinities (< 15 ppt) in general. Also, results from the October Station 3 census indicate that *P. vulgaris* is more likely to occupy wood and *P. pugio* the other substrates. Our field observations are in agreement with those of Thorp (1976), who found that *P. pugio* always occurred on muddy substrates and, with *P. vulgaris*, usually in shelly areas as well; the latter species was much less abundant on mud, especially in oligohaline creeks (wooden structures were not examined by him). The distribution along a salinity gradient (Fig. 5) may be accounted for, at least in part, by species differences in physiological tolerance of salinity and osmoregulatory capability. Knowlton and Schoen (1984) noted little difference in survivorship between the two species within the range 25-45 ppt, but much better survival of *P. pugio* below 20 ppt.

Data (e. g., Table 1) from pilot laboratory experiments established that grass shrimp (both species, whether alone or mixed together) generally distribute themselves randomly in the tank when all of their substrate choices are the same. If the animals exhibit clumping on a homogeneous substrate, then clumping on an array

of substrates may not be significant, and later test results would have been rendered meaningless. The change in dispersion pattern from random (as seen in the homogeneous substrate study) to clumped (as documented in the heterogeneous substrates experiment) suggests that in the former case individuals (of one or the other species) are not inherently attracted to each other and that in the latter case they passively allow other members of the same species to rest on the same substrate block.

Results of the main laboratory experiment (Figs. 7 and 8), in which individuals were presented a choice of substrates, are in agreement with the field-derived data. Following the same pattern seen in the field, in the laboratory setting *P. vulgaris* was most abundant on the wooden blocks occupying some of the cubicles, *P. pugio* on those covered with a mud veneer. In a similar study conducted by Arguin et al. (1989) both species exhibited a preference for wood, *P. vulgaris* moreso than *P. pugio*. The number of *P. pugio* (and *P. vulgaris*) on shell and sand was about the same in this and the present study, but *P. pugio* abundance on mud was considerably less (18%), and on wood more (39%), in the former experiment. A possible reason for this discrepancy is the fact that the mud used in the present experiment was more recently collected. This species is known to feed on selected mud meiofauna (Sikora, 1977; Bell and Coull, 1978; Smith and Coull, 1987) and detritus (Adams and Angelovic, 1970; Welsh, 1975); the "fresher" mud sample may have contained more food of this sort, thus rendering it more attractive. Also, in the Arguin et al. study the wooden blocks were positioned higher off the substrate (i.e., propped up a few cm on the partition edges in an effort to mimic the natural environment). Thus, more animals might have settled on the wood simply because, as a projection, it might have been encountered more often by animals swimming above the bottom. The presence of relatively large numbers of *P. pugio* on wood in both studies is consistent with Everett and Ruiz' (1993) observations (in the mesohaline Rhode River subestuary of Chesapeake Bay) of greater *P. pugio* densities around natural and experimental units of coarse woody debris (vs. areas lacking it).

The ANOVA (Table 2) showed that substrate selection in our experiment was influenced by salinity, a greater number of animals occurring on wood at 40 ppt than at 20 ppt, and significantly more animals being seen on mud at the lower salinity (Fig. 7). In mixed-species trials Arguin et al. (1989) found that at 20 ppt both species cohabited the wood in about equal numbers but at 40 ppt *P. vulgaris* was significantly more abundant on this substrate. From this they hypothesized that *P. vulgaris* is able to displace *P. pugio* from the "preferred" wood substrate at the higher salinity but not the lower one. In the present study, *P. vulgaris* predominated numerically over *P. pugio* on wood at both salinity levels. Differences in substrate selection attributable to both salinity and species were consistent but not statistically significant ($P = 0.2285$; Table 2) in our study.

According to the ANOVA, responses of *P. pugio* and *P. vulgaris* to a choice of substrates were not only significantly different, this choice was significantly influenced by the presence/absence of the other species, suggesting that some degree of interspecific competition occurs. Observations (Chambers, 1981, 1982; Ronald Gallin, unpublished data) of one-on-one interactions indicate that *P. vulgaris*, with stronger chelae, is indeed more aggressive and capable of displacing *P. pugio*. This may explain why a greater (average) number of *P. vulgaris* were seen on wood in

the mixed-species runs of our experiment (Fig. 8), i.e., it would be easier for individual *P. vulgaris* to "take over" the wooden blocks when half the individuals in the run were *P. pugio* rather than other *P. vulgaris*. Displacement of one species from a particular substrate by the other species, and reasons for it, could not be demonstrated in our study, in light of the results of the main experiment (significant factor interaction effects) and lack of documentation of the resources (e. g., types and amounts of food) they may compete for. However, displacement of *P. pugio* by *P. vulgaris* from shell to mud has been indicated in field and laboratory experiments carried out by Thorp (1976).

It is concluded that abundance and spatial distribution of *P. pugio* and *P. vulgaris* is strongly influenced by salinity and substrate, perhaps also temperature. Other factors such as tides and currents, water depth, light intensity, presence/absence of predators (e. g., the killifish *Fundulus*) and covering vegetation/woody debris, are also known to be important (Sikora, 1977; Heck and Orth, 1980; Coen et al., 1981; Kneib, 1984, 1987; Posey and Hines, 1991; Khan, 1992; Everett and Ruiz, 1993; Ruiz et al., 1993) but were not investigated in this study. Noting the decrease in *P. vulgaris* abundance (relative to *P. pugio*) with decreasing average salinities at the five stations (Fig. 5) and virtual absence of this species where ambient salinity was less than 13 ppt (Sta. 5), it is quite clear that salinity is an important abiotic factor limiting the distribution of *P. vulgaris* in Chesapeake Bay. In areas where *P. vulgaris* is absent, *P. pugio* is ubiquitous on wood as well as mud, sand, and shell. In areas of higher salinity, where the two species are sympatric, differential substrate selection may be an important aspect of resource partitioning, minimizing competition and promoting species coexistence. The reasons for the apparent preference for mud by *P. pugio*, and wood by *P. vulgaris*, as exhibited both in the field and in the laboratory experiment, have yet to be discerned. A mud surface offers an array of food types (meiofauna, detritus, etc.) favored by *P. pugio*. On the other hand, *P. vulgaris*, with stronger chelae, may be "attracted" to a wooden surface in order to prey on the epifauna harbored by algae, bryozoans, tunicates, and other encrusting organisms; or to seek protection from predation (as Everett and Ruiz, 1993, have demonstrated for *P. pugio*). Yet, in the laboratory experiments, *P. vulgaris* (and, to a lesser extent, *P. pugio*) frequented wood that was bare (i. e., bore no macroscopic periphyton), and in the field shrimp were commonly seen on pilings with little algal growth. Also, unanswered questions remain regarding the mechanism used by one species to displace the other, but our results support Thorp's (1976) contention that interference competition is an important separating mechanism for these two species where they are sympatric.

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Estimated Methane Production by Fauna Under Anthropogenic Influence in Virginia

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ABSTRACT

Methane production by fauna in Virginia was studied at a county-wide scale to determine and characterize regions of methane productivity. Rockingham, Clarke, Augusta, and Wythe counties ranked in the upper fifth percentile of production (> 1,538,719 kg/ha/yr) while Arlington, Buchanan, Dickenson, and Northampton were in the lowest fifth percentile (< 138,306 kg/ha/yr). Because of their high abundance and methane output, cattle constituted the bulk of faunal methane produced in Virginia, and were the prevalent source of methane in counties producing the greatest amount of methane. Termites and deer also produced significant amounts of methane and accounted for a larger proportion of the total in counties producing lower amounts of methane.

INTRODUCTION

Air samples of various ages taken from ice cores in Antarctica and Greenland reveal that atmospheric methane levels have more than doubled during the last century (Craig and Chou, 1982; Stauffer et al., 1985; Khalil and Rasmussen, 1987). Recent findings estimate that the global concentration of atmospheric methane (CH_4) is increasing annually at a rate of 16.6 ± 0.4 ppbv, or 1.02 ± 0.02% (Khalil and Rasmussen, 1990). Increased atmospheric methane concentrations may lead to elevated global temperatures, depletion of hydroxyl radicals (OH) in the troposphere, an increase of stratospheric and tropospheric ozone (O_3), increased atmospheric carbon monoxide (CO), and increased water vapor in the stratosphere (Khalil and Rasmussen, 1985).

The rise in the concentration of atmospheric methane can be attributed to two main factors. The first is elevated methane emissions. Methanogenic bacteria found in the guts of enterically fermenting animals such as cows and termites account for a large portion (15-25%) of global methane production (Crutzen et al., 1986). Anaerobic habitats such as aquatic sediments and lowland rice fields also emit substantial amounts of methane (Sheppard et al., 1982). The rise in methane emissions corresponds with increasing numbers of cows and rice fields needed to feed a growing human population (Ehhalt, 1985). Increasing methane concentrations may also be related to a depletion of its major sink, tropospheric hydroxyl radicals, resulting from an increase in carbon monoxide levels (Khalil and Rasmussen, 1985).

Because of the potential environmental change implicated with increases in methane concentration and its relation to human activities, many studies have attempted to quantify methane production. However, most have only considered

global or hemispheric scales. Here, I report the geographic distribution of methane production by fauna at a county-wide scale for Virginia. Smaller scale studies may yield better estimates of the distribution of methane production relative to land use patterns, at a scale where remediation is possible. Furthermore, small scale distributions provide an important tool in assessing any local or regional effects of methane.

METHODS

To estimate methane production by faunal sources at the county scale, estimates of both methane production rates per animal and the abundances of methanogenic animals in each county were needed.

Animals selected were those considered to be major producers of methane and for which methane production rates and abundance were known, or could be calculated. This included most mammalian livestock as well as deer. Small mammalian herbivores such as voles and woodchucks have no established methane production values, but may be a source of small amounts of methane. I used rates of methane production for mammals from Crutzen et al. (1986). Cows have the highest production rate (55.0 kg/cow/year), followed by horses (18.0 kg/horse/yr), deer (15.0 kg/deer/yr), sheep (8.0 kg/sheep/yr), and pigs (1.5 kg/pig/yr). Humans have a rather low methane production rate of 0.05 kg/human/yr. Wood and cellulose eating insects such as termites, as well as some cockroaches and beetles also emit methane, however only termites have available methane production data. For termites, I used a production rate of 0.146×10^{-6} kg/termite/yr (Zimmerman et al., 1982).

Population numbers for livestock were taken from the Census of Agriculture (1987). Deer populations were estimated for each county by multiplying the percent of the total 1990 quarry taken by hunters for a particular county by the estimated Virginia deer population of 850,000 (Virginia Department of Game and Inland Fisheries, 1991). This approach assumes a consistent hunting effort from county to county. Human populations are from the 1990 US census (US Bureau of Census, 1990). I evaluated termite densities for three habitat types. Temperate forest was estimated to have 600 termites/m^2, and termite density for cultivated land was estimated to be 2831 termites/m^2 (Zimmerman et al., 1982). Because these two habitat types are not inclusive of all possible termite habitats, I used a value of 400 termites/m^2 for habitats not included in forested or cultivated land. This value is somewhat more conservative than for agricultural and forested habitats because it includes areas uninhabitable by termites (e.g. lakes), however this category also includes urban and suburban areas which may support high termite densities. Areas of each county were taken from the 1990-91 report of the Secretary of the Commonwealth, forested acres were taken from the 1985 survey of timberland (Virginia Department of Forestry, 1986), and agricultural acreage was taken from the 1987 census of agriculture. The sum of agricultural and forested land was subtracted from the total county area to arrive at an area for the third habitat category.

To calculate faunal methane production, abundances of each animal in each county were multiplied by their respective production rate (kg/individual/yr). Gross methane production was divided by the area of each county to generate a

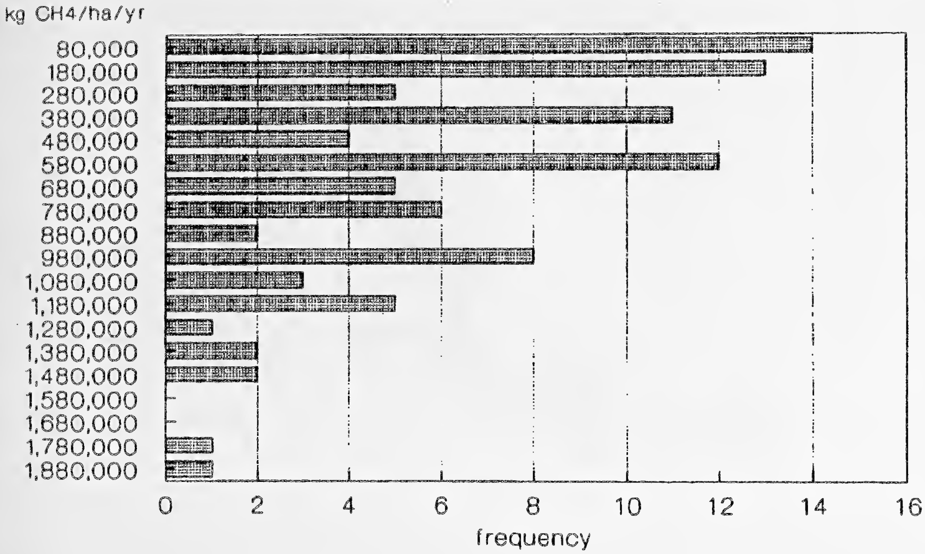

FIGURE 1. The frequency distribution showing the number of counties versus methane production (thousand kg/ha/yr). Midpoints of the classes were separated by 100,000 kg/ha/yr. Mean county methane production was 665,889 46,361 and ranged from 70,966 to 1,965,033 kg/ha/yr.

methane production rate per unit area. To characterize productive regions, methane production per hectare was plotted for each county and used to create a map of faunal methane production. Complete data for Suffolk, Chesapeake and Virginia Beach counties, as well as incorporated cities were not available, and were not used in any analysis.

To evaluate differences in the sources of faunal methane between counties producing high or low amounts of faunal methane, the percentage of the gross methane production attributable to each source was compared between counties in the uppermost quartile, the middle 50%, and in the lowest quartile of methane production per hectare using multivariate analysis of variance (MANOVA). Before analysis percentages from each source were arcsine square-root transformed to better meet the assumptions of homoscedasticity and normality (Sokal and Rohlf, 1981).

RESULTS

The total faunal methane production for Virginia was estimated to be 112,186,000 kg methane/yr. By virtue of their high production rate and abundance, cows accounted for 74.1%, or 83,101,000 kg/yr of the faunal methane produced in Virginia. Termites produced 13,643,000 kg/yr, or 12.0% of the total production, followed by deer producing 12,751,000 kg/yr or 11.4%. Pigs, horses, sheep, and humans together produced 1,600,000 kg/yr and accounted for < 3% of the total faunal methane production.

Mean county-wide faunal methane production for Virginia was 665,889 ± 46,361 kg/ha/yr. The distribution of methane production by individual counties

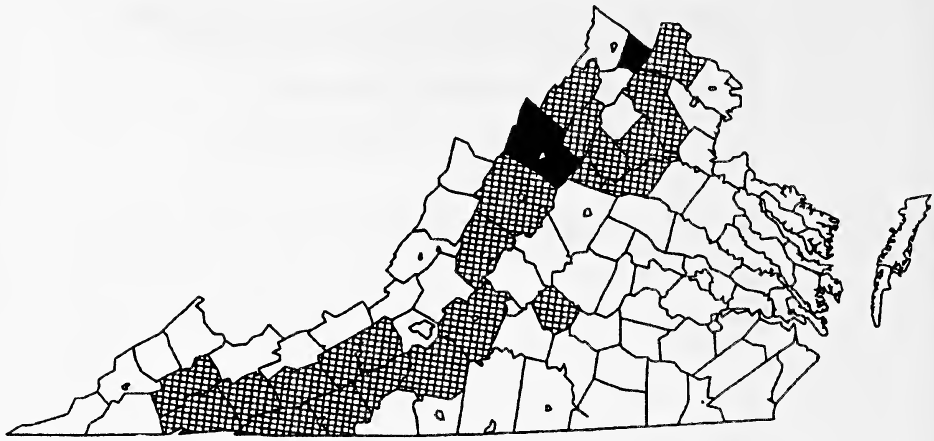

FIGURE 2. The distribution of methane production by county in Virginia. Counties producing greater than 1,800,000 kg/ha/yr are indicated by a solid pattern. Those with methane production between 1,200,000 and 1,800,000 are crosshatched, and those less than 600,000 are outlined only. Areas for which no data was available appear as open areas within counties or have no outline (see text).

(Figure 1) ranged from 70,966 to 1,965,033 kg/ha/yr, and was skewed to the right, i.e. counties with low production were closer to the mean than counties with high production. Rockingham, Clarke, Augusta, and Wythe counties were in the upper fifth percentile of methane production (> 1,538,719 kg/ha/yr), while Arlington, Buchanan, Dickenson, and Northampton, were in the lowest fifth percentile (< 138,306 kg/ha/yr).

Faunal methane production in Virginia showed a general increase moving from east to west, with the lowest areas being along the coast (Figure 2). Areas of high faunal methane production were generally in the western part of the state, in and around the Blue Ridge and Shenandoah Valley regions.

The contribution of sources of faunal methane production showed significant differences between counties in the highest quartile, middle 50%, and lowest quartile of gross methane production (MANOVA, Hotelling's $T^2 = 2.74$, approx. $F_{14} = 17.44$, $P < 0.00$). Univariate F-tests also showed significant differences in the percent composition of methane sources between counties producing high, medium, and low amounts of faunal methane for all sources except horses (Table 1). Cows, deer, and termites dominated methane production across all methane production levels. The proportion of total production attributable to bovine sources showed a general increase as gross faunal methane production increased, whereas the proportions from deer and termites tended to decrease with increasing methane production (Table 2).

DISCUSSION

This study shows that regionally high faunal methane production is generally a function of cattle farming. Percent composition data tends to confirm that cows

TABLE 1. Univariate F-tests comparing the arcsine square-root transformed percentage of gross methane production comprised by each source between counties producing high (upper 25th percentile), moderate (middle 50th percentile), and low (lowest 25th percentile) amounts of methane.

	Hypoth. MS	Error MS	$F_{2,98}$	P
DEER	0.37437	0.02612	14.33297	0.000
COWS	2.22362	0.02993	74.28289	0.000
PIGS	0.02014	0.00609	3.30471	0.041
HORSES	0.00633	0.00205	3.09413	0.050
SHEEP	0.02713	0.00257	10.56508	0.000
HUMANS	0.07782	0.00648	12.00986	0.000
TERMITES	0.82930	0.01213	68.34851	0.000

TABLE 2. Means and standard errors of the percentage of gross methane production for each methane source in counties producing high (upper 25th percentile), moderate (middle 50th percentile), and low (lowest 25th percentile) amounts of methane.

Source	High (N=24)	Moderate (N=50)	Low (N=25)
DEER	0.07 ± 0.01	0.19 ± 0.01	0.26 ± 0.04
COWS	0.82 ± 0.01	0.61 ± 0.03	0.29 ± 0.03
PIGS	0.00 ± 0.00	0.01 ± 0.00	0.02 ± 0.00
HORSES	0.01 ± 0.00	0.01 ± 0.00	0.02 ± 0.00
SHEEP	0.01 ± 0.00	0.01 ± 0.00	0.00 ± 0.00
HUMANS	0.00 ± 0.00	0.00 ± 0.00	0.03 ± 0.02
TERMITES	0.09 ± 0.00	0.17 ± 0.01	0.38 ± 0.03

are responsible for the bulk of production in counties that produce large amounts of methane, both because of their abundance and high methane production rate. Termites and deer tend to produce approximately equal percentages of methane in high production counties, while in counties with lower methane production termites become the major source. Counties (e.g. Arlington) that are generally more urban, have smaller deer and livestock populations, and thus produce less methane from faunal sources. Termites however, are fairly ubiquitous and may be a major source of methane in all areas.

Land usage may be a good predictor of methane production. Unlike most atmospheric pollution problems (e.g. carbon monoxide), methane is associated with rural rather than urban or industrial areas. The counties producing the highest amounts of methane in Virginia tended to be agrarian counties, devoted to livestock farming. Identifying major sources of methane and typifying the productive regions provides an important first step towards any mediation of the problem.

Despite providing an approximation of faunal methane production this study has obvious limitations. Much conjecture also surrounds the importance of methane production by termites (cf. Collins and Wood, 1984). County-wide habitat data was available only for forested and agricultural land necessitating a catch-all category. This approximation introduces some error because the category encompasses habitats where no termites live and other areas of possible high density. Methane production also varies from termite species to species and is habitat and temperature dependant (Collins and Wood, 1984), thus finding an adequate estimate for both termite density and methane production is difficult.

Another limitation of this study is that it only considers faunal sources of methane, which globally account for only approximately 15-25% of methane emissions (Crutzen et al., 1986). Almost any anaerobic habitat produces methane. Production for wetlands, lakes, and streams are not included, and may comprise up to 75% of global methane emissions (Sheppard et al., 1982). These sources, however, are generally not under human control for and constitute 'natural' background methane emissions. Non-biogenic, anthropogenic sources, such as biomass burning, natural gas refining, and asphalt production were also not included in this analysis, and may account for 10-15% of global emissions (Sheppard et al., 1982). Thus the total amount of methane produced will be higher than would be estimated using only a faunal approach.

Despite these limitations, the results of this study show that agricultural counties, especially those devoted to cattle farming, may have high levels of methane production and that the bulk of faunal methane in Virginia is produced in the Shenandoah Valley region. Urban/suburban and crop farming counties tend to produce less faunal methane with non-bovine sources accounting for a greater proportion of the total.

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Expert Computer Software and the Unauthorized Practice of Law

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ABSTRACT

Expert systems are a class of intelligent computer programs which incorporate domain-specific facts and the reasoning capabilities of one or more human experts from the problem area. The purpose of an expert system is to use that stored knowledge to solve problems normally requiring human specialists (Firebaugh, 1989). The trend in computer programs developed for the legal market has been to incorporate more and more intelligent features, so that some programs in certain aspects are approaching the level of expert systems. If a computer program truly achieves the legal expertise of an attorney, it could possibly violate the strictures against the unauthorized practice of law. This paper describes the increasing sophistication of software used in legal practice, and addresses certain issues relating to the unauthorized practice of law by computer programs.

INTRODUCTION

Over the past ten years the functional equivalent of an industrial revolution in the application of computer technology to business and professional offices of all kinds has taken place. In 1982 the IBM Magnetic Card typewriter was nearly state of the art for word processing: a user could record a whole page on the envelope-sized piece of plastic. Shortly thereafter, typewriters with word processing capability, such as the Olivetti electronic typewriter equipped with about 16K of external storage, became available. Then came dedicated word processors, and then desk-top general purpose computers with word processing, file management, and spread sheet software. Recently the inclusion of graphical user interfaces has made office systems easier to use, and decision support systems, containing problem-related data and analytical modelling capability, are now available to help managers, executives, and professionals evaluate alternative solutions to problems before making decisions.

Over this same period of time a healthy market has developed selling increasingly sophisticated custom software to lawyers. One has only to look at the advertisements in any current issue of the *ABA Journal* for evidence of a large variety of commercial software packages available to assist attorneys with law office accounting, bankruptcy, debt collection, case management, searches, and so on.

THE EVOLUTION OF LEGAL SOFTWARE: BANKRUPTCY LAW EXAMPLE

A major portion of bankruptcy law practice consists of preparing comprehensive statements and schedules which list all of the assets and debts of the debtors. Information such as the name and address of a creditor, and the amount owed to that creditor by the debtor, might ultimately have to be entered on several different

forms. Naturally, it would be most efficient to use a computer, have the data entered only once and then automatically directed to the correct forms after the computer performs the appropriate mathematical computations.

Matthew-Bender, a major publisher in the legal market, has produced at least three generations of bankruptcy software which illustrate how legal software is evolving from simple forms generation toward expert systems level. The first generation, circa 1987, was fairly unsophisticated. The selection of forms available was quite small, and the entry process was quite primitive. Although the program had forms for petitions filed under Chapter 7[1] and Chapter 11[2], Chapter 13[3] was not serviced. There was no automatic routing of the data to forms. The user had to specify which forms onto which the data was to be recorded. The program performed only limited mathematical operations in totalling the amounts in the schedules, and could only hold the data for one bankruptcy at a time. Despite its limitations, using this program was a lot faster than sitting down at a typewriter to fill out the blank forms.

The second generation, circa 1989, was much more sophisticated. Not only were more forms available, but once data was entered into the program it was automatically routed to the forms. Still, the user had to manually select which forms were to be printed. Chapter 13 was now partially covered. Yet there was no default grouping of forms for printing. That is, the data was directed to the correct forms, but when the forms were to be printed, it was necessary to manually indicate which forms were relevant for the particular bankruptcy. The data input process did utilize limited branching, and the program could hold the data for several debtors at once. All in all, this package was a major advance.

The third generation appeared in 1991. This program used some branching logic in obtaining the data. For example, if an individual as opposed to a couple was filing bankruptcy, the program was finally smart enough that it did not ask superfluous questions about the debtor's spouse. Data was automatically sent to the forms, and the forms were automatically grouped for printing. This program was more adept in the data entry process, particularly in the portion of the program where the assets of the debtor had to be entered. The primary limitation of this version was in the preparation of the Chapter 13 Plans. A form was provided wherein the specifics of

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1 Chapter 7 Bankruptcies involve the liquidation of a debtor's estate. The debtor reveals to the court the location and value of all property owned. Technically, certain items of property could be taken and sold under court supervision, and the proceeds applied on a pro rata basis to the debts owed by the debtor, though in about 98% of cases, no property is actually sold. The balance of the unpaid debts would be discharged, meaning that the legal obligations to pay the debts are wiped out.

2 A Chapter 11 bankruptcy generally involves the reorganization of a business, though individual debtors may also file. In general terms, the purpose of a Chapter 11 is to hold the creditors of a debtor at bay while the business is allowed to operate until a plan of reorganization can be filed with the court and accepted by the creditors.

3 Chapter 13 is available only to individuals. This a powerful option, especially for debtors who have fallen in arrears on mortgage payments, and are in danger of losing the property securing the debt, which is typically their residence. The debtor proposes in the Chapter 13 Plan a payment plan between 36 and 60 months in length. This plan can cure the default in a mortgage by completely amortizing the arrearage, with interest over the term of the plan. In addition, up to 70% of a debtor's unsecured debts can be discharged through payments in the plan.

a Chapter 13 plan could be entered, but the program itself did not carry out the computations necessary to formulate the plan. The user had to prepare a template using a spread sheet program that computed the monthly payments for the Chapter 13 Plan. While this was adequate, the user was still required to exit the program, determine the sums of debts owed as computed by the bankruptcy program, enter the data on the spreadsheet, and then return to the bankruptcy program.

Recently Matthew-Bender announced that they have a new, improved release of the program ready to ship. Perhaps this version will contain the ability to compute a Chapter 13 plan entirely within the program and will include a decision support subsystem for determining whether a particular debtor could file under a given Chapter of the bankruptcy code. From this point, the next logical step would be to create future versions which could include expert system reasoning and rules to actually recommend the various bankruptcy options.

Some of these capabilities are already available in at least one commercial program for computing Federal Tax returns (Meca, 1992). In that program the user is asked questions, and from his responses, is presented with follow-up questions as needed. The user has the ability to see what would be the consequences of alternative choices in tax strategies. Clearly the tax program approaches expert level in its sophistication. What may not be apparent is that in the legal arena, if a computer program with legal expertise approaches expert level, it is possible that such a program might actually pass into the realm of the unauthorized practice of law.

LIMITATIONS ON THE PRACTICE OF LAW

In the United States, an individual has a constitutional right to represent himself or herself[4] in Court. However, there is no corresponding right to represent any other individual or otherwise practice law. Each individual state or jurisdiction strictly controls who may practice law within that state. In most jurisdictions, Statute or Rules adopted by the Courts limit the practice of law to members of the Bar.

Generally speaking, to be admitted to the bar the applicant must graduate from a properly accredited law school, and pass a very rigorous bar exam lasting two or three days. A recent trend has been to require a certain amount of annual continuing legal education for bar membership. Furthermore, a member of the bar is subject to the discipline of the Courts in the event of malfeasance in the representation of clients.

An individual who attempts to practice law without having the requisite bar membership faces potential criminal prosecution[5]. In addition, Courts may issue injunctive relief prohibiting repetition of the offending conduct[6].

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4 However, note the observation apocryphally attributed to Abraham Lincoln that the person who represents himself in court "has a fool for a client and a lawyer".

5 By statute, any person practicing law without being duly authorized or licensed is guilty of a misdemeanor", Rules of the Supreme Court of Virginia, Virginia Rules Annotated, Pt. 6, Sect. I.

6 "The courts of the Commonwealth have the inherent power, apart from statute, to inquire into the conduct of any person to determine whether he is illegally engaged in the practice of law, and to enjoin such conduct". Rules of the Supreme Court of Virginia, Virginia Rules Annotated, Pt. 6, Sect. I.

WHAT IS THE UNAUTHORIZED PRACTICE OF LAW?

In the state of Virginia, one who is a non-lawyer engages in conduct deemed to constitute the unauthorized practice of law occurs whenever:

> 1: One undertakes for compensation . . . to advise another . . . in any matter involving the application of legal principles to the facts or purposes or desires.[7]
>
> 2: One . . . undertakes, with or without compensation, to prepare for another legal instruments of any character, other than notices or contracts incident to the regular course of conducting a licensed business.[8]
>
> 3: One undertakes with or without compensation, to represent the interest of another before any tribunal.[9]

Theoretically then, a computer program could approach the level of unauthorized practice of law under either or both of the first two bases cited above. A program by itself purporting to directly advise a client of the application of legal principles to a particular set of facts could be viewed as the practice of law. In other words, a computer program is close to practicing law if, after engaging the client in an interactive dialogue to determine the specific facts of the case, it can tell the client, "You are qualified to file a Chapter 13 Bankruptcy, and you should file because of the following reasons ...". A similar conclusion could be reached if the program prepared the schedules and statements to be filed in the particular bankruptcy without review by an attorney.

JUDICIAL ANALYSIS

Determinations of whether the unauthorized practice of law has taken place are made in Courts through the judicial process. A review of reported appellate decisions was unable to find a case directly on point discussing whether a computer program was the unauthorized practice of law. But the day may not be far in the future when such a case will be before the courts. The evolution of computer hardware and software is moving at a very fast pace. As previously noted, some income tax preparation programs already incorporate expert system-like attributes. Furthermore, software is now being sold to the general public enabling ordinary individuals to create and liquidate limited partnerships without the aid of an attorney (Nolo, 1993).

The American Court system frequently uses reasoning through analogy, and relies upon similar cases as precedent for future decisions. Therefore guidance as to what a court might do with the issue of whether a computer program is the unauthorized practice of law may be found in reviewing how the court has treated similar cases. The closest series of cases found dealt with the issue of whether there is the unauthorized practice of law in the sale of books or forms designed to enable non-lawyers to achieve legal results without assistance of an attorney.

7 Rules of the Supreme Court of Virginia, Virginia Rules Annotated, Pt. 6, Sect. I(B)(1).

8 Rules of the Supreme Court of Virginia, Virginia Rules Annotated, Pt. 6, Sect. I(B)(2).

9 Rules of the Supreme Court of Virginia, Virginia Rules Annotated, Pt. 6, Sect. I(B)(3).

It is a rare occasion for an attorney--even a sole practitioner--to sit down and create a document or legal pleading that is completely novel. Instead, the attorney would locate as a model an existing document that comes as close as possible to meeting the current needs, and then modify that model document as necessary to fit the facts at hand. Typical sources of the model document are the prior work product of either the drafting attorney, or his or her associate. From the model, a photocopy can be made, modified and retyped, or more commonly, downloaded from an electronic file and modified using a word processing program. In addition, there are many commercial publishers that produce for the legal market form books containing sample pleadings. Also, certain forms, especially forms for the conveying of real property, sample lease agreements, bills of sale, and so on, are typically available in stationery or business supply stores. Finally, many courts provide samples of the forms required for certain types of matters which may come before it. This is especially true for probate courts and small claims courts.

The Florida Supreme Court in the case of The Florida Bar v American Legal and Business Forms, Inc. (Florida, 1973) noted that the printing and sale of legal forms in and of themselves without more purported instructions, has been a practice for many years as a convenience, from a variety of sources. <u>The court found no harm in having printed legal forms and copies of statutes available, provided they do not carry with them instructions on how to fill out such forms or how they are to be used. Such instructions would be viewed as constituting legal advice and the unauthorized practice of law</u>. The matters to be weighed and considered in determining what rights are to be pursued do not generally appear in the pleading filed with the court.

In the case of Palmer v The Unauthorized Practice Committee of the Texas State Bar (Palmer, 1974), it was held that the sale of will forms constituted the unauthorized practice of law, on the ground that it was indistinguishable from the preparation of a full legal document for a client because such forms purported to make particular dispositions of property. The court focused on its view that the exercise of judgment in the proper drafting of legal instruments, or even the selecting of the proper form of instrument, necessarily affects important legal rights. Accordingly, the reasonable protection of those rights required that the persons providing such services be licensed members of the legal profession. <u>The Court asserted that a non lawyer may have read defendant's materials, and be misled into believing that all testamentary dispositions may be thus standardized. Such a misconception could lead to unfortunate consequences for anyone who might rely upon the form</u>.

In the case of The Florida Bar v Stupica (Florida, 1974), an individual produced a document styled as a "Divorce Kit", designed specifically to be used in a no-fault dissolution of marriage proceedings. The Florida Bar sought injunctive relief barring the advertisement, publication or sale of this "Divorce Kit". The Defendant contended that the "Divorce Kit" was merely a law book or pamphlet publication of legal forms combined with allowable explanatory data and instructions. These arguments were rejected by the Court. The court held: <u>The advice given in the "Divorce Kit" as to the use of the forms is quite comprehensive and specific. It parallels much of what an attorney would customarily advise his clients who seek dissolution of marriage</u>.

Finally, other courts have focused their analyses not on the content of the forms or kits provided, but instead on whether there has been established an individual attorney-client relationship. For example, in the case of New York County Lawyer's Asso. v Dacey (New York, 1967), the Court ruled there is no practice of law unless there is a personal relationship established between the client and the person presuming to practice for the purpose of giving and receiving particular legal advice on a particular problem. The mere sale of a book containing forms and advice on how to use the forms was therefore not the practice of law. Similar reasoning was used to allow the marketing of "do-it-yourself" divorce kits in the cases of New York State v Winder (New York, 1973) and Oregon State Bar v Gilchrist (Oregon, 1975).

THE QUESTION OF ACCOUNTABILITY

The cited basis of the prohibition against the unauthorized practice of law is a concern that the interest of the public be protected.[10] There may indeed be cause for legitimate concern in this area. When it comes to legal matters, a little knowledge is truly a dangerous thing, and serious consequences can indeed flow from inept legal advice or performance. An attorney who is inept or negligent in representing his clients is subject to sanction by the Court and may be disbarred. But who is accountable if a computer program gives erroneous or incomplete advice? Likewise, if an attorney participates in the writing of expert legal software which does give correct advice, what are the ramifications of that attorney not being licensed in the state where the software is actually used?

The ultimate resolution of many legal matters is simple. But the problem is, such matters are often deceptively simple. What is not simple is the process by which the appropriate course of action is selected. What one pays for when one retains an attorney is the benefit of his or her expertise in determining just how simple the problem is. An expert system is based on rules, and it may be difficult to devise rules that would be sufficiently complete to cover all factors, especially if the conclusions were to be directed to laymen.

THE QUESTION OF COST VS BENEFIT

Programs that truly approach the level of being expert systems have so far been difficult and expensive to produce, and the market for these programs has been rather limited. Only a small percentage of the population will consider filing bankruptcy in any given year. Accordingly, the unit cost will be fairly high. The bankruptcy program mentioned above retailed for about $700.00 in 1991. An

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10 "The services of a lawyer are essential and in the public interest whenever the exercise of professional legal judgment is required. The essence of such judgment is the lawyer's educated ability to relate the general body and philosophy of law to a specific legal problem. The public is better served by those who have met rigorous educational requirements, have been certified of honest demeanor and good moral character, and are subject to high ethical standards and strict disciplinary rules in the conduct of their practice....With the increase in the complexity of our society and its laws, the independence and integrity of a strong legal profession, devoted disinterestedly to those requiring legal services, are crucial to a free and democratic society. Allegiance to this principle, rather than the preservation of economic benefits for lawyers, is the basis upon which the Virginia State Bar, as the Administrative agency of the Supreme Court of Virginia, carries forward the responsibility for the discipline of lawyers and the investigation of persons practicing law in the commonwealth without proper authority." Rules of the Supreme Court of Virginia, Virginia Rules Annotated, Pt. 6, Sect. I.

attorney might charge $350.00 or less for a Chapter 7 Bankruptcy. Therefore, a potential bankrupt debtor will have little incentive to purchase an expert grade bankruptcy computer program for one time use, even if the program does an adequate job. It would be cheaper to hire an attorney.

Compare this potential bankruptcy program with the tax return preparation program mentioned earlier. Everyone files a tax return every year. The program in question cost approximately $34.00 retail. The development costs for the program can be spread over a relatively large base of potential users. If the cost of developing this program were to be spread over a much smaller base, the individual cost would be much higher, perhaps approaching that of the bankruptcy program.

On the other hand, the limited partnership program also mentioned above retails for about $129.00, while the cost of hiring an attorney to create a limited partnership might be upwards of $350.00, and the cost to liquidate one might be $200.00 or more. In this case it would be more cost effective to buy the program than to hire an attorney, especially if the potential user has a personal computer and is comfortable using it.

CONCLUSIONS

In the not too distant future, more computer programs will be marketed that will be sufficiently advanced such that the programs will be capable of addressing problems now thought to require the professional attentions of an attorney. In short, they will be expert systems. Because of the potential for error or misuse, and because of the lack of direct accountability, such programs could in certain circumstances constitute the unauthorized practice of law.

But the issue of the unauthorized practice of law will be a major factor <u>only</u> to the extent the programs are marketed to the general public as <u>substitutes</u> for the lawyer. If the cost of commercial legal software for the general public continues to fall, it may become widely used by a generation which is computer-literate. Then related cases may very well be brought to the attention of the courts.

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Fishes of the Main Channel New River, West Virginia.

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ABSTRACT

Fishes were collected at five sites within a 92-km section of the New River in southern West Virginia in 1988, 1989, and 1990, and compared to previous surveys from 1979 and 1984. A total of 42 species were collected, representing five orders and eight families. Twenty of the 42 species (48 percent) are considered introduced to the drainage. A low number of native species (22 native species) was collected since 1979 and indicates a relatively depauperate fish fauna. Of the six endemic species in the New River drainage, only the bigmouth chub *Nocomis platyrhynchus* was common; the others were rare or not collected. Species richness was higher at the site immediately below Bluestone Dam compared to sites further downstream. New main channel distributional records were documented for gizzard shad and mountain redbelly dace.

INTRODUCTION

The New River drainage harbors few indigenous fishes but a relative wealth of endemics (Ross and Perkins, 1959; Jenkins et al., 1972; Hocutt et al., 1986; Jenkins and Burkhead, 1994). Several authors have attributed the uniqueness of New River fish fauna to factors such as high gradient, hard bottom, poorly developed flood plain, (Addair, 1944; Ross and Perkins, 1959), high dissolved sulfates (Ross and Perkins, 1959), and isolation caused by several major falls (Jenkins et al., 1972; Hocutt et al., 1986). Previous counts have reported a total of 88 fish species in the New drainage with 46 native species including six endemics (Jenkins and Burkhead, 1994).

The scenic beauty and unique features of the New River inspired the creation of the New River Gorge National River (NRGNR) in 1978. The NRGNR is a 90-km corridor located in West Virginia and administered by the U.S. Department of the Interior, National Park Service. There are few published accounts of the fish fauna in this reach of the New River from which to develop a baseline for future monitoring (Stauffer et al., 1980; Hess 1983; Lobb, 1986). In this paper we summarize the fish species collected during 1988, 1989, and 1990 and past fish surveys for a current checklist of the fish fauna in the main channel New River.

METHODS

Five study sites (Bluestone Dam, Sandstone Falls, Prince, Thurmond, and Fayette Station) were sampled in the New River (Figure 1). The Bluestone Dam site (latitude 37° 38' 37", longitude 80° 53' 5") is located immediately downstream

1 Present address: Environmental Resources Management, Inc., 2666 Riva Road, Suite 200, Annapolis, Maryland 21401

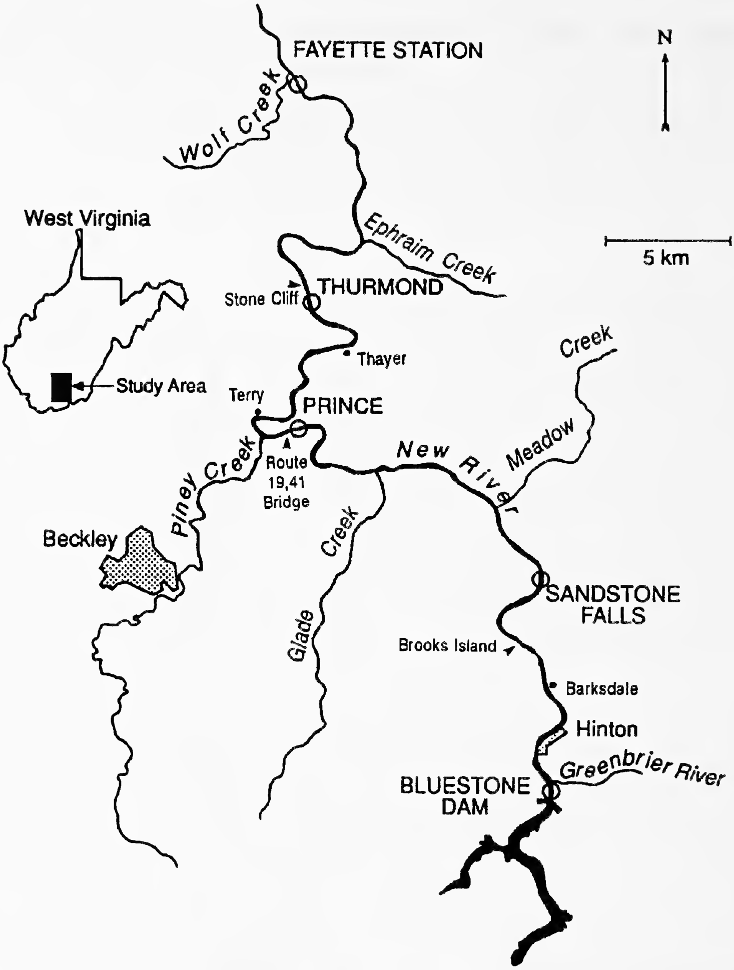

FIGURE 1. Map of study sites (open circle), cities (shaded area), towns (filled circles), and landmarks (arrow) on the New River, WV.

of Bluestone Dam. At this site the New River is approximately 300 m wide with an average depth of 1 m at low summer flow. Samples were collected in a section extending from 100 to 300 m downstream of Bluestone Dam. Samples were collected along the right descending river margin and in the main channel around rock outcrops and *Justicia americana* (water willow) islands.

The Sandstone Falls site (latitude 37° 46' 15", longitude 80° 53' 37") is located approximately 16 river km downstream of Bluestone Dam. At this site the river is approximately 300 m wide with an average depth of 1 m at low summer flow. Samples were collected in a section extending from 100 to 500 m upstream of Sandstone Falls. Samples were collected along the left descending river margin and in the main channel around water willow islands.

The Prince site (latitude 37° 51' 13", longitude 81° 4' 28") is located approximately 41.5 river km downstream of Bluestone Dam. At this site the river is approximate-

ly 150 m wide with wadable depths (less than 1 m) only along the margins. Samples were collected from a section extending from 100 to 500 m upstream of the route 19 and 41 bridge. All samples were collected along the left descending river margin.

The Thurmond site (latitude 37° 55' 53", longitude 81° 3' 52") is located approximately 61.5 river km downstream of Bluestone Dam. At this site the river is approximately 150 m wide with wadable depths (less than 1 m) only along the margins. Samples were collected from a section extending from 100 to 500 m upstream of Stone Cliff. All samples were collected along the left descending river margin.

The Fayette Station site (latitude 38° 3' 57", longitude 81° 4' 45") is located approximately 91.5 river km downstream of Bluestone Dam. At this site the river is approximately 50 m wide with wadable depths (less than 1 m) only along the margins. Samples were collected from a section extending from 100 to 500 m upstream of the confluence of the New River and Wolf Creek. All samples were collected along the left descending river margin.

Samples were collected in 1988, 1989, and 1990 from all five sites in mid to late summer (August and September). Additional samples were collected each year from Bluestone Dam and Sandstone Falls in early summer (June and July) and mid-fall (October and November). A total of 27 collections were made.

Twenty six of the 27 collections were made by electrofishing with a canoe-mounted generator, Coffelt (VVP-2C) control box and two hand-held electrodes. Each collection consisted of thirteen 10-minute electrofishing periods using pulsed DC electricity. In 1988, at Fayette Station, fish were collected during ten 10-minute sampling periods using a Coffelt electrofishing boat. During a 10-minute sample period all stunned fish were netted and placed in either a live well or bucket. After each 10-minute sample period, all large and familiar species were recorded and released. All other specimens were either stored on ice or preserved with 5-10% formalin. In the laboratory all specimens were identified using Jenkins and Burkhead (1994).

Sampling by Stauffer et al. (1980) was conducted in June and August of 1979. Collections were made by electrofishing into a 1.5 m X 3.0 m seine. For each collection, sampling was conducted until additional effort produced no additional species. For consistency, collections from several locations were pooled to represent collections at Bluestone Dam, Sandstone Falls, Prince, and Thurmond (Figure 1). Bluestone Dam was represented by six collections made between Bluestone Dam and the city of Hinton. Sandstone Falls was represented by four collections made between Brooks Island and the mouth of Meadow Creek. Prince was represented by one collection at the mouth of Piney Creek. Thurmond was represented by one collection immediately upstream of Stone Cliff.

Sampling by Lobb (1986) was conducted at each site from July to October of 1984. Collections were made using a raft-mounted generator, Coffelt (VVP-2C) control box, and two hand-held electrodes, a Coffelt electrofishing boat, a Coffelt backpack electrofisher, and by electrofishing into a seine. Each collection consisted of a 15-minute electrofishing period. For consistency, collections from several locations were pooled to represent collections at Bluestone Dam, Sandstone Falls, Prince, and Thurmond (Figure 1). Bluestone Dam was represented by five collections made between Bluestone Dam and the town of Barksdale.

Sandstone Falls was represented by 33 collections made between Brooks Island and 0.5 km downstream of the mouth of Meadow Creek. Prince was represented by 36 collections made between the mouth of Glade Creek and 3.3 km downstream of the town of Terry. Thurmond was represented by 26 collections made between Thayer and the mouth of Ephraim Creek. No collections were made by Lobb (1986) near the Fayette Station site.

For the purposes of this paper and as was done by Lobb (1986) no distinction was made between *Luxilus albeolus* white shiner and *L. chrysocephalus* striped shiner. The authors believe that both species inhabit this section of the New River; however, distinction of the two species proved to be problematic. Stauffer et al. (1980) reported only white shiners from this section of the New River. *Luxilus* spp. were not included in species counts. In order to discuss commonness and rarity of species we defined common as a species which occurred in more than 10 of the 13 site surveys and rare as a species which occurred in fewer than three of the 13 site surveys.

To allow for discussion of sampling efficiency, an estimate for species richness (Krebs, 1989) was used to calculate absolute species richness and a 95 percent confidence interval at each of the five sites for the 1988 to 1990 mid-summer collections only.

For discussion of longitudinal variation in species richness, total species richness was tabulated for the 1988-1990 survey and for all three surveys combined. Total species richness was not calculated separately for Stauffer et al. (1980) and Lobb (1986) because of unequal sampling effort among sites.

RESULTS AND DISCUSSION

A total of 42 fish species (not including both *Luxilus* spp.) and one recognized hybrid, from eight families and five orders were collected in the New River between Bluestone Dam and Fayette Station from 1979 to 1990 (Table 1). Jenkins and Burkhead (1994) reported 88 fish taxa known from the New drainage and 42 (48 percent) of these they considered introduced. Twenty (48 percent) of the 42 fish species listed in Table 1 are considered introduced (Jenkins and Burkhead, 1994). Addair (1944) reported 25 fish species from the main channel of the New River between Bluestone Dam and Fayette Station with nine (36 percent) introduced species (Jenkins and Burkhead, 1994). Orth and Leonard (1985) reported 28 fish species from the main channel of the New River near Prince and Thurmond with ten (36 percent) introduced species (Jenkins and Burkhead, 1994). The low number of native fish species (22 native species) collected between Bluestone Dam and Fayette Station since 1979 further supports previous discussions of the depauperate fish fauna of the New drainage (Ross and Perkins, 1959; Jenkins et al., 1972; Hocutt et al., 1986; Jenkins and Burkhead, 1994).

Main channel distribution records for the 1988-1990 survey include *Dorosoma cepedianum* gizzard shad and *Phoxinus oreas* mountain redbelly dace. To our knowledge this is the first published account of gizzard shad within the New drainage. One individual was collected on October 31, 1989, from the Bluestone Dam site and 13 specimens were collected from the Bluestone Dam (12 fish) and Thurmond (1 fish) sites in 1990. Two individuals collected on November 1, 1990, at Bluestone Dam exceeded 400 mm TL and one specimen was 480 mm TL.

TABLE 1. List of species collected in the New River between Bluestone Dam and Fayette Station in 1979, 1984, 1988, 1989, and 1990 (X denotes species was collected).

Species	Origin[a]	Bluestone Dam			Sandstone Falls			Prince			Thurmond			Fayette Station
		79	84	88-90	79	84	88-90	79	84	88-90	79	84	88-90	88-90
Clupeidae														
Dorosoma cepedianum (Lesueur) gizzard shad	I			X									X	
Cyprinidae														
Campostoma anomalum (Rafinesque)[c] central stoneroller	N	X	X	X	X	X	X	X	X	X		X	X	
Cyprinella galactura (Cope) whitetail shiner	IP			X			X			X			X	
Cyprinella spiloptera (Cope)[bc] spotfin shiner	N	X		X	X	X			X	X		X	X	X
Cyprinus carpio Linnaeus[bc] common carp	I			X	X	X								
Luxilus spp. (Rafinesque)[c] white and/or striped bass	NI	X	X	X	X	X	X	X	X	X	X	X	X	
Nocomis platyrhynchus Lachner &Jenkins[c] bigmouth chub	E	X	X	X	X	X	X		X	X	X	X	X	X
Notemigonus crysoleucas (Mitchill) golden shiner	I	X		X										
Notropis hudsonius (Clinton)[c] spottail shiner	IP	X		X	X	X	X		X	X			X	X
Notropis photogenis (Cope)[c] silver shiner	N	X		X	X	X	X		X			X	X	
Notropis rubellus (Agassiz)[bc] rosyface shiner	N	X		X	X	X	X	X	X	X	X	X	X	
Notropis telescopus (Cope)[c] telescope shiner	IP	X	X	X	X	X	X	X	X	X	X	X	X	X
Notropis volucellus (Cope)[bc] mimic shiner	N	X		X	X	X		X	X	X	X	X	X	X

TABLE 1. *continued*

Species	Origin[a]	Bluestone Dam 79	84	88-90	Sandstone Falls 79	84	88-90	Prince 79	84	88-90	Thurmond 79	84	88-90	Fayette Station 88-90
Cyprinidae *continued*														
Phoxinus oreas (Cope) mountain redbelly dace	N						X							
Pimephales notatus (Rafinesque)[bc] bluntnose minnow	NI	X	X	X	X	X		X	X	X		X	X	
Rhinichthys atratulus (Hermann)[b] blacknose dace	N	X			X									
Rhinichthys cataractae (Valenciennes)[bc] longnose dace	N	X			X	X		X	X	X		X	X	
Semotilus atromaculatus (Mitchell)[b] creek chub	N			X			X							
Catostomidae														
Catostomus commersoni (Lacepéde) white sucker	N	X												
Hypentelium nigricans (Lesueur)[bc] northern hog sucker	N	X	X	X	X	X	X	X	X	X	X	X	X	X
Ictaluridae														
Ameiurus natalis (Lesueur) yellow bullhead	IP	X		X			X			X				X
Ictalurus punctatus (Rafinesque)[bc] channel catfish	N			X			X			X				X
Pylodictis olivaris (Rafinesque) flathead catfish	N	X	X	X	X	X	X		X	X	X	X	X	X
Atherinidae														
Labidesthes sicculus (Cope)[c] brook silverside	I	X			X	X			X			X		

TABLE 1. *continued*

Species	Origin[a]	Bluestone Dam 79	84	88-90	Sandstone Falls 79	84	88-90	Prince 79	84	88-90	Thurmond 79	84	88-90	Fayette Station 88-90
Percichthyidae														
Morone chrysops (Rafinesque) x *Morone saxatilis* (Walbaum) sunshine bass	I			X								X		
Centrarchidae														
Ambloplites rupestris (Rafinesque)[bc] rock bass	I	X	X	X	X	X	X	X	X	X	X	X	X	X
Lepomis auritus (Linnaeus) redbreast sunfish	I		X	X		X	X		X	X		X	X	X
Lepomis cyanellus Rafinesque[b] green sunfish	N	X		X			X			X		X		X
Lepomis gibbosus (Linnaeus)[c] pumpkinseed	I	X		X		X				X		X		
Lepomis macrochirus Rafinesque[bc] bluegill	I	X	X	X	X	X	X	X	X	X		X	X	X
Lepomis megalotis (Rafinesque) longear sunfish	I								X	X				X
Micropterus dolomieu Lacepéde[bc] smallmouth bass	I	X	X	X	X	X	X	X	X	X		X	X	X
Micropterus punctulatus (Rafinesque)[bc] spotted bass	I	X	X	X	X	X	X	X	X	X		X	X	X
Micropterus salmoides (Lacepéde)[b] largemouth bass	I			X		X	X			X			X	
Pomoxis annularis Rafinesque[b] white crappie	I	X		X	X	X			X					X
Pomoxis nigromaculatus (Lesueur)[b] black crappie	I	X		X	X					X				

TABLE 1. *continued*

Species	Origin[a]	Bluestone Dam 79	Bluestone Dam 84	Bluestone Dam 88-90	Sandstone Falls 79	Sandstone Falls 84	Sandstone Falls 88-90	Prince 79	Prince 84	Prince 88-90	Thurmond 79	Thurmond 84	Thurmond 88-90	Fayette Station 88-90
Percidae														
Etheostoma blennioides Rafinesque[bc] greenside darter	I	X	X	X	X	X	X	X	X	X	X	X	X	X
Etheostoma caeruleum Storer[c] rainbow darter	NI	X	X	X	X	X	X	X	X	X		X	X	X
Etheostoma flabellare Rafinesque fantail darter	N	X												
Perca flavescens (Mitchill) yellow perch	I				X									
Percina caprodes (Rafinesque)[c] logperch	N	X		X		X			X	X		X	X	X
Percina gymnocephla Beckham[d] Appalachia darter	E							X						
Percina oxyrhynchus (Hubbs & Raney) Sharpnose darter[bc]	N	X		X	X	X		X	X	X	X	X	X	X
Percina roanoka (Jordan & Jenkins)[c] Roanoke darter	IP	X	X	X	X	X	X	X	X	X	X	X	X	X

[a]N = native; E = endemic; NI = regarded as native, but possibly introduced; IP = regarded as introduced, but possibly native; I = introduced; taken from Jenkins and Burkhead (1994).
[b]reported from the mainstem New River between Bluestone Dam and Fayette Station by Addair (1944); also reported *Anguilla rostrata* (Lesueur) American eel, *Erimystax dissimilis* (Kirtland) streamline chub, *Notropis scabriceps* (Cope) New River shiner, and *Stizostedion vitreum* (Mitchill) walleye.
[c]reported from the mainstem New River near Prince and Thurmond by Orth and Leonard (1985); also reported *Lythrurus ardens* (Cope) rosefin shiner and *Notropis scabriceps* (Cope) New River shiner.
[d]reported as *Percina maculata* blackside darter.

Carlander (1969) reports sizes for gizzard shad greater than 480 mm TL only after age-5. If the 480 mm TL individual collected in 1990 was a lifelong resident of the New River, then gizzard shad entered the New drainage prior to 1986. Gizzard shad were also collected in Bluestone Lake by West Virginia Department of Natural Resources (WVDNR) personnel in 1989 (Mark Scott, pers. comm.) and Claytor Lake by Virginia Department of Game and Inland Fisheries (VDGIF) personnel in 1988 (Joe Williams, pers. comm.). An article in the September 10, 1992 edition of the Roanoke Times and World-News (page C3) referred to an anonymous phone-caller who claimed to have stocked thousands of gizzard shad from Smith Mountain Lake of the Roanoke drainage into Claytor Lake of the New drainage over a five-year period in the mid-to-late 1980's.

Whitetail shiners, which were introduced from Tennessee River drainage, have previously been recorded from main channel and tributary sections of the New River in Virginia and upper regions in West Virginia (Jenkins et al., 1972; Lee et al., 1980; Stauffer et al. 1980; Hess 1983); however, this is the first account from the lower New River in West Virginia (Prince and Thurmond). Previous authors have suggested that the fauna of New River is unsaturated, at least in parts of the drainage, possibly because of barriers such as reservoirs (Jenkins et al., 1972; Hocutt et al., 1986). During the spring of 1989, frequent high flows may have carried larval whitetail shiners downstream to the lower New River.

The appearance of mountain redbelly dace in the main channel of the New River in West Virginia is probably not evidence for established populations in the main river; however, it may be a result of a few transient individuals being washed into the river from tributaries during flooding. Jenkins and Burkhead (1994) indicate that the mountain redbelly dace is more common in upland, mountain streams and creeks than large rivers such as the New River. Mountain redbelly dace have previously been collected in tributaries of the New River in West Virginia (Leonard and Orth, 1986; Hocutt et al., 1978).

Morone chrysops x *M. saxatilis* sunshine bass, the one recognized hybrid collected by both Lobb (1986) and the authors, have been stocked intermittently in Bluestone Reservoir between 1976 and the present (Mark Scott, pers. comm.) and probably entered the New River through the dam. *Morone chrysops* white bass and *Morone saxatilis* striped bass were stocked by the WVDNR in Bluestone Reservoir in 1955 and 1975, respectively (Mark Scott, pers. comm.). Moreover, the latter species has been stocked in Virginia portions of the New River by VDGIF from 1969 to the present (Joe Williams, pers. comm.). Another species known to be stocked in the New River drainage and not collected in any of the three surveys is *Esox masquinongy* muskellunge, which were observed in underwater surveys in 1984 (Lobb and Orth, 1991). WVDNR has stocked muskellunge in Bluestone Reservoir intermittently from 1958 to the present (Mark Scott, pers. comm.) and VDGIF has stocked muskellunge in Virginia portions of the New River since 1963 (Joe Williams, pers. comm.). *Esox lucius* x *E. masquinongy* tiger muskellunge were stocked by VDGIF in Virginia portions of the New River in the late 1970's and early 1980's (Joe Williams, pers. comm.). Several trout species (*Oncorhynchus mykiss* rainbow trout, *Salmo trutta* brown trout, and *Salvelinus fontinalis* brook trout) are stocked annually by the WVDNR in the tributaries of the New River between Bluestone Dam and Fayette Station (Mark Scott, pers. comm.); however, none of

these species were collected in the three surveys listed herein. Other species stocked historically in Bluestone Reservoir by WVDNR include: *Dorosoma petenense* threadfin shad in 1965, 1966, and 1971; *Notropis atherinoides* emerald shiner in 1962, and *Stizostedion vitreum* walleye intermittently between 1976 and 1983 (Mark Scott, pers. comm.).

Three New River drainage fish species (New River shiner, *Phenacobius teretulus* Kanawha minnow, and candy darter) have previously been mentioned as species of special concern due to low numbers, limited distributions, or recent declines (Johnson, 1987; Burkhead and Jenkins, 1991). None of these species occurred in the surveys listed in Table 1 and only the New River shiner has ever been reported from the main channel of the New River between Bluestone Dam and Fayette Station (Addair, 1944; Orth and Leonard, 1985).

Fifteen of the 42 species collected are considered common and nine other species are considered rare. Common species include *Campostoma anomalum* central stoneroller, bigmouth chub, *Notropis rubellus* rosyface shiner, *N. telescopus* telescope shiner, *N. volucellus* mimic shiner, *Hypentelium nigricans* northern hog sucker, *Pylodictis olivaris* flathead catfish, *Ambloplites rupestris* rock bass, *Lepomis macrochirus* bluegill, *Micropterus dolomieu* smallmouth bass, *M. punctulatus* spotted bass, *Etheostoma blennioides* greenside darter, *E. caeruleum* rainbow darter, *Percina oxyrhynchus* sharpnose darter, and *P. roanoka* Roanoke darter. Rare species include gizzard shad, *Notemigonus crysoleucas* golden shiner, mountain redbelly dace, *Rhinichthys atratulus* blacknose dace, creek chub, *Catostomus commersoni* white sucker, *Etheostoma flabellare* fantail darter, *Perca flavescens* yellow perch, and Appalachia darter.

Absolute species richness estimates varied both spatially and temporally (Figure 2). The absolute species richness was greatest at Prince in 1990 and lowest at Fayette Station in 1990. The 95 percent confidence interval for absolute species richness estimates indicate that sampling efficiency of species numbers was generally good during 1988-1990 mid-summer collections. Ten of the actual species richness values fell inside the 95% confidence interval for absolute species richness, while the remaining five collections were just outside the lower range of this confidence interval.

The greatest number of fish species was collected from Bluestone Dam (38 species) with decreasing numbers of species occurring with distance from Bluestone Dam (Figure 3). However, sampling effort was greatest near Bluestone Dam. The same trend was less distinct for collections made 1988-1990, when sampling effort remained equal among all five sites. Species numbers may be greatest immediately downstream of Bluestone Dam due to emigration of game and forage species from Bluestone Lake. Introduced species collected only at Bluestone Dam or Sandstone Falls include common carp, golden shiner, and yellow perch. Species numbers may decrease with distance from Bluestone Dam due to reduced habitat diversity; for example, Lobb (1986) found that in general, channel width decreased and gradient increased with distance from Bluestone Dam.

ADDENDUM

In subsequent routine surveys of the New River the European cyprinid, rudd

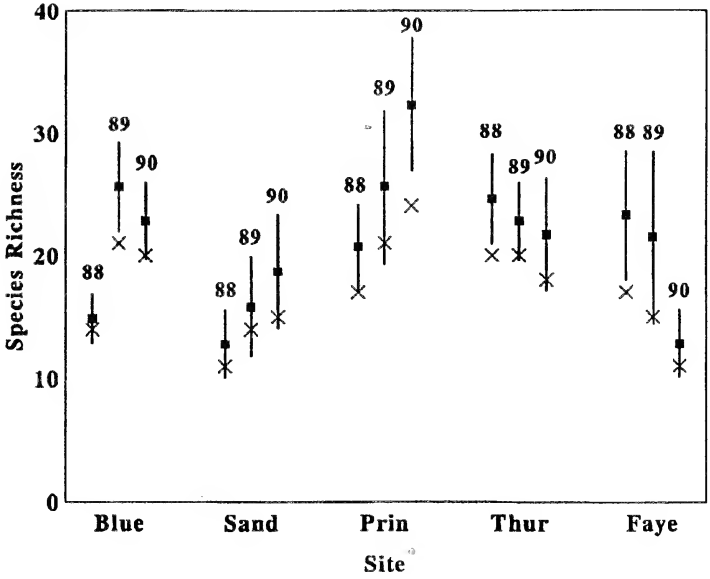

Figure 2. Absolute species richness estimates (square), 95 percent confidence interval for the absolute species richness estimates (vertical bar), and actual species richness values (X) for mid-summer collections at Bluestone Dam, Sandstone Falls, Prince, Thurmond, and Fayette Station in 1988, 1989, and 1990 (88 = 1988, 89 = 1989, 90 = 1990, Blue = Bluestone Dam, Sand = Sandstone Falls, Prin = Prince, Thur = Thurmond, Faye = Fayette Station).

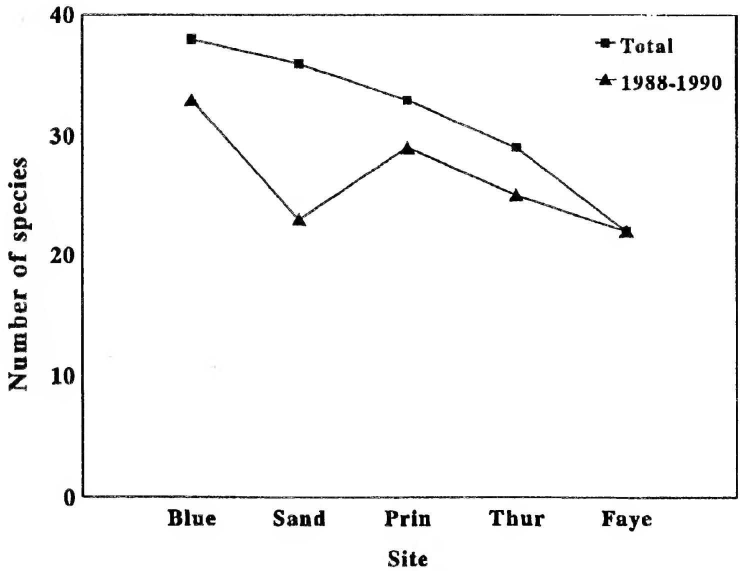

Figure 3. A site comparison of the total number of species collected in all three New River, WV studies with the total number of species from the 1988-1990 surveys (Blue = Bluestone Dam, Sand = Sandstone Falls, Prin = Prince, Thur = Thurmond, Faye = Fayette Station).

Scardinius erythrophthalmus was collected in the main channel New River near Stone Cliff in Fayette County, West Virginia (Easton et al. 1993).

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Graminicolous Fungi of Virginia: Fungi Associated with Cereals

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ABSTRACT

The fungi listed and annotated in this paper include those reported in publications and collected and identified by the authors within the Commonwealth of Virginia on the cereal grasses, barley, corn, oats, rye, grain sorghum, and wheat. Fungi on two or more hosts are usually listed as plurivorous fungi; those restricted to one host in Virginia are listed as specific fungi. Species better known by their anamorphic binomials are dually listed. An alphabetical summary of all species is included.

INTRODUCTION

Many fungi have been reported to occur on grasses in Virginia, but these reports are widely scattered in check lists, experiment station publications, and scientific journals. It would be difficult for anyone seeking information on graminicolous fungi to survey completely the pertinent literature. The recent compendium, "Fungi on Plants and Plant Products in the United States," (Farr et al., 1989) provides the most comprehensive list available. If a fungus has been reported in the literature to occur in Virginia, it will probably be listed by Farr et al. However, a number of fungi are known to occur on cereals and other grasses in Virginia which have not been the subject of publications and, therefore, are not listed by them. In addition, since 1989, we have collected and identified fungi on many grasses growing in diverse ecological sites that have never been reported in a particular host-fungus relationship in Virginia and, in some cases, the United States. It is our purpose to provide an annotated list by host of the graminicolous fungi of Virginia. Pertinent literature will be cited and where deemed helpful, synonymy will be included.

Since this endeavor may result in a lengthy publication, we have considered presenting the list in segments, namely, fungi on cereals, on turfgrasses, on forage grasses and on wild or uncultivated grasses. Division into these categories may create some complications because a number of host species can be included in two or more categories. For example, *Cynodon dactylon*, *Poa pratense*, and *Festuca arundinacea* may be included in three categories and *Dactylis glomerata* and *Phleum pratense* may be included in two categories. However, we have decided to follow the scheme of Farr et al., namely, to list the noncereal grasses in alphabetical order and provide a summarizing index to the fungus species included. This will make our findings more readily useful to pathologists and mycologists.

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Nomenclature provides us with some challenges. Groups of grasses (formerly Gramineae, now Poaceae) and fungi are being studied continually and changes especially in genera occur such that only professional taxonomists have ready access to the most recent binomials. Therefore, to simplify our problem, generally we will use the binomials listed by Farr et al. (1989) for both grasses and fungi; exceptions will be noted. Our aim, however, is to identify a particular host-fungus association and not to get bogged down in recognition or rejection of nomenclatorial changes. It will be necessary, in some cases, especially with fungi, to provide synonymy, anamorphs and teleomorphs (even sometimes suspected) in our annotations.

This project emerged from recognition of literature deficiencies while teaching various courses at Virginia Polytechnic Institute and State University (VPI & SU) such as Diseases of Field Crops, Clinical Plant Pathology, and Plant Disease Fungi; aiding in diagnosis of grass and cereal disease in the Plant Clinic; encountering new or unfamiliar diseases while carrying out research projects; a lack of recognition of the graminicolous fungi in the natural history of Virginia; and finally satisfying curiosity about the identity of graminicolous fungi encountered on various excursions. An annotated list of fungi associated with cereal grasses will be presented first.

THE CEREALS

The cereals cultivated in Virginia include oats, *Avena sativa* L.; barley, *Hordeum vulgare* L.; rye, *Secale cereale* L.; sorghum, *Sorghum bicolor* (L.) Moench.; wheat, *Triticum aestivum* L.; and corn or maize, *Zea mays* L. Varieties or subspecies of these species such as *Z. mays* subsp. *saccharata*, sweet corn; *Z. mays* subsp. *indentata*, dent corn; and *Z. mays* subsp. *everta*, popcorn, are grown in Virginia. A number of species of barley, oats, and wheat have been grown in experimental nurseries in Virginia but they have not been hosts to any unusual fungi; therefore, only the crop species cultivated in Virginia will be included in our lists.

THE FUNGI

Some fungi are plurivorous; some are specific. To conserve space, we will first list the plurivorous fungi of cereals; then we will list the fungi specific for each host species. Within each list, fungi will appear in taxonomic rank; an alphabetical summary will be provided.

A. Plurivorous fungi.

Myxomycota:

Polymyxa graminis Ledingham. This fungus colonizes roots of numerous grasses. It is economically important because it harbors and transmits the viruses causing wheat soil-borne mosaic (WSBMV), wheat spindle streak mosaic (WSSMV) and oat soil-borne mosaic (OSBMV) (Roane, 1960; Tolin & Roane, 1969). These virus diseases were known in Virginia many years before the fungus was associated with them. The fungus has been identified in roots of the following collected in 1981-82- 83: barley from Frederick, Northumberland, Nottoway, and Westmoreland Cos.; oats and rye from Richmond Co.; wheat from Caroline, Charles City, Dinwiddie, Essex, Gloucester, King and Queen, Richmond, and Westmoreland Cos. and the cities of Chesapeake, Virginia Beach, and Suffolk; corn

from Hanover, Richmond, and Sussex Cos. The two wheat viruses, WSBMV and WSSMV, are widespread in the Coastal Plain and Piedmont, and OSBMV is known from Charlotte, Richmond, and Mecklenberg Cos. Therefore, *P. graminis* must be widely distributed in the eastern half of Virginia. Its presence in barley, rye, and corn in the United States was first reported in 1983; its presence in oats in Virginia was also first reported in 1983 (Roane & Roane, 1983).

Mastigomycotina - Oomycetes:

Sclerophthora macrospora (Sacc.) Thirum., G. C. Shaw, and Naras. is widespread on grasses in the northern hemisphere. We have identified it from collections of the following: oats, from Henrico and Richmond Cos.; barley, Henrico; wheat, Henrico; corn, City of Suffolk (Nansemond Co.), and Wythe Co. The Henrico collections were from a single field of small grain "succotash" on the State Prison Farm (Roane & Fenne, 1955). In corn, the fungus causes "crazy top", a disease that was known for many years before the causal agent was determined (Ullstrup, 1952). The Suffolk collection came from a field at Chuckatuck having a mixture of corn and sorghum. Nearly all the corn had crazy top but no sorghum plants displayed symptoms although sorghum is a known host of the fungus (Roane, 1960). Although Farr et al. (1989) list it as occurring on rye in Virginia, we have not seen it.

Ascomycotina:

Claviceps purpurea (Fr.:Fr.) Tul., the cause of ergot, occurs on numerous grasses worldwide. In Virginia, even though it commonly occurs on rye, collections on rye have been made only from Accomack and Montgomery Cos.; on barley it occurred regularly on spring sown plants in a genetic study at Blacksburg, Montgomery Co. (1960-1968); we have a single specimen on wheat in the classroom collected from somewhere in Virginia. Ergot pseudosclerotia contain powerful toxins which cause a variety of symptoms in animals (Christensen et al., 1977). However, several useful drugs may be extracted from pseudosclerotia.

Cochliobolus sativus (Ito & Kuribayashi) Drechsl. ex Dastur, the teleomorph of *Bipolaris sorokiniana* (Sacc.) Shoemaker, better known in older literature as *Helminthosporium sativum* Pammel, King and Bakke, is found most often in Virginia as a defoliating fungus of barley. However, it has been collected from seedling blighted wheat in Virginia. The teleomorph may be produced in culture but is not found in nature.

Erysiphe graminis DC. (now *Blumeria graminis* (DC.) E. O. Speer), the powdery mildew fungus, occurs on numerous grasses worldwide. There are four *formae speciales*, *avenae*, *hordei*, *secalis*, and *tritici*, all of which occur in Virginia. Only f.sp. *avenae* is unusual in that it produces no cleistothecia. Powdery mildew occurs in most barley and wheat fields but it is less common on rye. We have a collection on rye only from Montgomery Co. Because it is so common, we have neglected to deposit it in our collection.

Gaeumannomyces graminis (Sacc.) Arx & D. Olivier, the cause of "take-all" of cereals and grasses, occurs sporadically throughout Virginia, primarily in wheat fields. It is well-known as a wheat pathogen in eastern United States and the VPI & SU Plant Clinic records document numerous occurrences on wheat. Although

it has not been reported on barley in Virginia previously, collections have been made from barley fields in Augusta in 1954, Montgomery Co. in 1956.

Gibberella zeae (Schwein.) Petch (anamorph, *Fusarium graminearum* Schwabe) is the cause of seedling blight, stalk and ear rot of corn, seedling blight and scab of small grains. The perithecia of the fungus occur in superficial clusters, giving the appearance that a scab has been formed. This fungus is broadly distributed (Anonymous, 1960; Farr et al., 1989); in Virginia, it occurs frequently causing head blight and scab of wheat, rye, and barley and occasionally a node rot of barley (Westmoreland Co., photographic record). Scab and head blight are more severe following corn in crop rotations or in fields adjacent to corn stalks and stubble from the previous summer. In corn, it is widespread as a cause of red stalk and ear rot, probably occurring to some degree in all corn fields. Perithecia commonly occur on overwintering corn stalks; *G. fujikuroi* (Sawada) Ito & K. Kimura also overwinters in this manner and is macroscopically identical to *G. zeae*. It produces 2-celled ascospores, but *G. zeae* produces 4-celled ascospores. Scabby grain may contain powerful toxins such as vomitoxin, T-2, and zearalenone, which cause various symptoms including poor weight gain in cattle and swine (Christensen et al., 1977). A destructive scab epidemic occurred in wheat and barley in Virginia in 1972 (Roane & Starling, 1976).

Pyrenophora tritici-repentis (Died.) Drechsl., anamorph, *Drechslera tritici-repentis* (Died.) Shoemaker, causes tan or yellow leaf spot of rye and wheat. The ascomycetous stage occurs on dead and fallen straws in late summer and overwinters there. Leaf spots have been collected from rye at three locations in Montgomery Co. On file are leaf collections from wheat in Montgomery and Dinwiddie Cos.; it has also been found on wheat from Charles City, Richmond, and Westmoreland Cos. (E. L. Stromberg, personal communication).

Basidiomycotina - Ustilaginales:

The smut fungi which occur regularly on small grains in Virginia have very confusing synonymy; we will follow the nomenclature given by Fischer in the "Manual of North America Smut Fungi" (1953).

Ustilago avenae (Pers.) Rostr. causes a black loose smut of oats and barley. The finely echinulate spores are borne superficially on the seed. Infection takes place during seed germination.

Ustilago nuda (Jens.) Rostr. causes brown loose smut of barley, rye, and wheat. Spores are finely echinulate; infection occurs during flowering and the embryo is colonized.

Ustilago hordei (Pers.) Lagerh. (Fischer, 1953) causes covered smut of oats and barley. Spores are smooth; they are surface-borne on the seed and infection occurs during seed germination. Farr et al. (1989) list this fungus as *U. segetum* (Bull.:Pers.) Roussel.

All three fungi have been found in Virginia on hosts noted above but *U. nuda* is of most common occurrence on wheat and barley.

Basidiomycotina - Uredinales:

Puccinia graminis Pers., the black stem rust fungus, occurs on barley, oats, rye, wheat, and several grasses in Virginia. It is more common in western Virginia where

native barberry, *Berberis canadensis* Mill., its aecial host, occurs (Harvill et al., 1986), but in some years it spreads into Virginia from outbreaks of rust on wheat in states south of Virginia. The fungus occurs as six *formae speciales* of which *avenae*, *secalis*, and *tritici* occur on oats, rye, and wheat, respectively. *Puccinia graminis* f.sp. *secalis* and *tritici* will infect and colonize barley but stem rust on barley is rare in Virginia. Formerly, wheat and oats were widely grown in southwest Virginia; there, barberry was virtually eliminated from grain producing areas by 1975. Now, however, grain is produced mainly in the Piedmont and Coastal Plain. As a result, there are few recent reports of cereal stem rust in Virginia and, consequently, the barberry eradication project has been discontinued.

Deuteromycotina - Hyphomycetes:

Several fungi colonize senescent plant parts of all cereals under consideration here. They are generally saprophytes and are usually found together as co-colonizers. These include *Alternaria alternata* (Fr.) Keissl., *Cladosporium herbarum* (Pers.:Fr.) Link., *Epicoccum nigrum* Link, and *Heterosporium avenae* Oudem. These fungi have either dark colored spores or hyphae (or both); hence, their colonies are described as "sooty molds". Other dark colored species may on occasions be co-colonizers but these are found most commonly.

Aspergillus candidus Link, *A. flavus* Link:Fr., *A glaucus* Link:Fr., and *A. niger* Tiegh. are listed by Farr et al. (1989) to occur in Virginia on corn and wheat, probably in storage. All species commonly invade corn ears, kernels and sometimes cause seed rot in soil. Frequently, *A. flavus* occurs on corn in the field and is a rapid colonizer of exposed moist endosperm; therefore, harvested grain must be dried quickly. This fungus is feared because it produces aflatoxins which are carcinogenic mycotoxins; thus, it frequently is a cause of rejection by grain buyers (Christensen et al., 1977). We encounter these *Aspergillus* species in plating and germination experiments with corn and wheat.

Hymenula cerealis Ell. and Everh. (= *Cephalosporium gramineum* Nisikado and Ikata) was first found in the western states and recognized as *C. gramineum*; hence, the disease associated with it became "Cephalosporium" stripe. Cephalosporium stripe on wheat was found in 1975 (Roane & Starling, 1976) and again in 1979 (Jones et al., 1980) in Montgomery and Augusta Cos., respectively. We found it on rye in 1977 and 1979 in Montgomery Co. (Jones et al., 1980). These are the only reports of this disease from Virginia and surrounding states.

Rhynchosporium secalis (Oudem.) J. J. Davis causes scald of barley and rye. It is common on barley in Virginia but since it is sometimes controlled by growing resistant cultivars, seed treatment and crop rotation, it is not present in all fields. On rye we have collected it in Montgomery and Accomack Cos. from Experiment Station plantings.

Deuteromycotina - Coelomycetes:

Ascochyta spp. are pycnidiate fungi found on many grasses.

Ascochyta brachypodii (Sydow) Sprague and A. G. Johnson has broader spores than those of *A. sorghi*. It was collected on oat leaves from Richmond Co. in 1983 and on barley leaves from Northumberland Co. in 1992. Spores measured 18-20 *X* 4-5 μm. Those of *A. sorghi* are 11-21 *X* 1.6-4.0 μm, characteristically less than 4.0

μm wide (Sprague, 1950). Farr et al. (1989) do not list barley as a host. These are new records for *A. brachypodii* in the eastern United States.

Ascochyta hordei K. Hara produces pale yellow 1-septate spores sometimes constricted at the septum, 15-27 X 4.5-7.1 μm (mostly 20 X 5 μm). We have found it on wheat from Amelia, Montgomery, Northumberland, and Westmoreland Cos.; on barley from Amelia, Essex, King William, and Northumberland Cos., and in Montgomery Co. at several locations; and on rye from Cumberland Co. These are first reports of *A. hordei* in Virginia.

Ascochyta sorghi Sacc. produces hyaline spores 11-21 X 1.6-4.0 μm; widths are mostly 2.5-4.0 μm. Sprague and Johnson (1950) combined *A. graminicola* with *A. sorghi*. We have found *A. sorghi* on barley from Amelia Co. and from several locations in Montgomery Co.; on rye from Cumberland Co.; and on wheat from Caroline, Charles City, Montgomery, and Pittsylvania Cos. The Montgomery collection of 1973 was the first identified from wheat in eastern United States (Roane et al., 1974).

Colletotrichum graminicola (Ces.) G. W. Wils. is characterized by setose acervuli and falcate spores. It causes anthracnose and occurs on many grasses statewide, usually as a saprophyte but often as a pathogen. It occurs on all of the cereal grasses grown in Virginia. A collection on barley has been made from Montgomery Co.; on oats from Montgomery, Pulaski, and Rockingham Cos.; on rye from Isle of Wight Co.; on wheat from Goochland Co.; and on corn at several locations in Lancaster, Montgomery, Northumberland, and Richmond Cos. The fungus often produces lesions on corn seedling leaves but not on the upper leaves during the period of rapid growth. Later, it reappears on senescing leaves and stalks, sometimes causing premature dying and breakage. A 10-acre spring-sown field of oats at Belspring in Pulaski Co. was observed to have anthracnose on 100 percent of the plants examined at the milk to soft dough stage of grain development. Later the oats were completely lodged; the grain was of no value. This was the most damaging incident of anthracnose ever observed on a small grain crop in Virginia.

The reports above suggest that anthracnose is of spotty occurrence. Most likely, it could be found in all grain fields if a search were made.

Deuteromycetes - Other:

Rhizoctonia solani Kuehn - Three species of *Rhizoctonia* are listed by Farr et al. (1989) as occurring on grasses. Each has a distinct teleomorph. However, without applying intricate techniques, it is difficult to tell from an anamorph which species one has encountered. Therefore, *R. cerealis* Van der Hoeven, *R. solani* and *R. zeae* Voorhees will be lumped together under *R. solani*, the oldest of the three binomials. The teleomorph is *Thanatephorus cucumeris* (A. B. Frank) Donk. *Rhizoctonia* spp. cause root rots and the sharp eyespot of grasses. Sharp eyespot was first found on barley in 1957 (Roane & Starling, 1958); since then we have found *R. solani* causing sharp eyespot of barley in yield trial nurseries in Accomack, Augusta, Charlotte, Chesterfield, Montgomery, Orange and Richmond Cos. and the City of Suffolk (formerly Nansemond Co.). It has been detected in numerous commercial barley fields but no records for them are available. Sharp eyespot is frequently detected when small patches of barley plants have "whiteheads" as a result of Rhizoctonia infection. Sharp eyespot has been found on oats in

Montgomery Co. and on wheat in nurseries at locations listed above for barley and on commercial wheat from Essex Co. In 1994, wheat specimens with sharp eyespot were received by the Plant Clinic from Chesapeake, Dinwiddie, and Westmoreland Cos. In the past, it has been most prevalent as a barley disease in Virginia. Our report of 1958 (Roane & Starling) was the first to indicate sharp eyespot occurred east of the Mississippi River.

B. Fungi specific on host species.

Avena sativa L. - oats

Mastigomycotina:

Pythium graminicola Subramanian - Sprague (1950) is erroneously cited by Farr et al. (1989) as having reported this fungus from Virginia. Although the fungus is widespread, we cannot verify this report.

Ascomycotina:

Claviceps purpurea (Fr:Fr) Tul. occurs in the Eastern States (Farr et al., 1989) but there is no record of its occurrence on oats in Virginia.

Cochliobolus victoriae R. R. Nelson, anamorph, *Bipolaris victoriae* (Meehan and Murphy) Shoemaker was common on oats in Virginia from 1950 until the early 1960's when resistant oat varieties replaced susceptible ones. No victoria blight has been observed on oats in Virginia since 1965. The teleomorph apparently does not occur in nature but may be produced in the laboratory by pairing compatible cultures.

Phaeosphaeria avenaria (G. F. Weber) O. Eriksson, most often recognized by its anamorph, *Septoria avenae* Frank, is listed by Farr et al. (1989) as being in this region. We have been unable to locate it; therefore, it is of questionable occurrence in Virginia.

Pyrenophora avenae Ito and Kuribayashi is better known in its anamorphic stage, *Drechslera avenae* (Eidam) Scharif, formerly *Helminthosporium avenae* Eidam, as the cause of oat leaf blotch, the commonest leaf disease of oats in Virginia. Collections are on file from Bedford and Montgomery Cos. Perithecia form on overwintering straw.

Basidiomycotina:

Puccinia coronata Corda, the crown rust fungus, gets its name from the teliospores which are adorned by projections suggesting a small crown. Although we have no collections of the fungus on oats, it is well known in Virginia. The aecial hosts in Virginia are buckthorns, *Rhammus caroliniana* Walt. and *R. cathartica* L.

Deuteromycotina - Hyphomycetes:

Bipolaris sorokiniana (Sacc.) Shoemaker the anamorph of *Cochliobolus sativus*, is listed by Farr et al. (1989) on oats from the eastern states. We have not collected it.

Fusarium avenaceum (Fr.:Fr.) Sacc. was isolated from oat roots collected from experimental nurseries in Montgomery Co. in 1949 (Roane, 1949).

Hordeum vulgare L. - barley

Ascomycotina:

Several common ascomycetous fungi on barley occur in Virginia only in hyphomycetous stages (anamorphs); their ascomycetous (teleomorphs) stages occur rarely in nature; therefore, they are described in most lists under Hyphomycetes. Most of those from Virginia were listed under plurivorous fungi.

Pyrenophora teres Drechsl., anamorph *Drechslera teres* (Sacc.) Shoemaker, is a seedborne fungus and, consequently, is widely distributed. It occurs to some degree on foliage in all barley fields in Virginia. The teleomorph occurs on oversummering and overwintering straw and is quite easy to find. Although there are numerous records of its occurrence on file at the VPI & SU Plant Clinic, and we have collected it frequently for classroom use, we have no accessions in our collection of Virginia graminicolous fungi.

Basidomycotina - Uredinales:

Puccinia hordei Otth is the only rust commonly found on barley in Virginia. Its appearance is predisposed by the distribution of susceptible cultivars; until recently, resistant cultivars were widely grown in Virginia. A new race has invalidated this resistance. The rust commonly occurring on wheat in Virginia, *P. recondita* Rob. ex Desmaz, is reported as occurring on barley in Virginia (Anonymous, 1960); however, we do not know the original source of that report nor have we ever found it. *Puccinia hordei* can produce its spermagonial and aecial stages (O, I) on *Ornithogalum umbellatum* L., star of Bethlehem, which is widely scattered in the State but we have been unable to find these stages on naturally occurring *O. umbellatum*, even where the rust occurred on barley in adjacent fields (Roane & Starling, 1958). We have produced these stages by overlaying a bed of *O. umbellatum* with straw bearing telia of *P. hordei*. Collections of stages II and III are on file from Northumberland and Montgomery Cos.

Basidiomycotina - Ustilaginales:

Although the following *Ustilago* species were listed under plurivorous fungi, further comment is warranted here. *Ustilago nuda* (Jensen) Rostr. - Three barley head smut fungi have occurred in Virginia, of which *U. nuda*, causing brown loose or deep loose smut, is the most common. This is a "flower infecting" smut which survives as dormant mycelium in infected embryos. It has been controlled through use of hot water seed treatments and chemical seed dressings which are absorbed by germinating seeds and which thereafter function as systemic fungicides to inhibit the further development of the mycelium in the embryo.

The other smut fungi, *U. avenae* (Pers.) Rostr., causing semi-loose or black loose smut and *U. hordei* (Pers.) Lagerh., causing covered smut, are "seedling infecting" fungi. Their spores are killed or infection is inhibited more easily by chemical seed dressings than are those of *U. nuda*. Seedsmen devote much effort to the control of smuts in seed stocks.

Deuteromycotina - Hyphomycetes:

Drechslera graminea (Rabenh.) Shoemaker causes barley stripe. This disease is seedborne and therefore is controlled by fungicidal seed dressings. It occurs

when control measures are not implemented and can destroy 50% or more of the plants from a given seed lot. It occurs sporadically throughout barley producing areas of Virginia.

Deuteromycotina - Coelomycetes:

Septoria passerinii Sacc. causes leaf blotch and is widespread in Virginia. We have collections from five experiment station test locations around the State and specimens are frequently submitted to the VPI & SU Plant Clinic for diagnosis. The morphology is similar to that of *S. nodorum* (Berk.) Berk., which is very common on wheat in Virginia.

Secale cereale L. - rye.

Most fungi we have encountered on rye are plurivorous and have been listed previously. Only four additional fungi need be annotated.

Basidiomycotina - Ustilaginales:

Urocystis occulta (Wallr.) Rabenh. ex. Fuckel, the cause of flag smut, is reported by Farr et al. (1989) as occurring in Virginia. We are unable to find the source of this report. We presume that it is from records kept by F. D. Fromme, James Godkin or S. A. Wingard in the 1915-1940 era. It has not been seen in Virginia for several decades.

Basidiomycotina - Uredinales:

Puccinia recondita Roberge ex Desmaz. occurs on rye throughout Virginia. It is less damaging on rye than on wheat; see under wheat.

Deuteromycetes - Coelomycetes:

Dinemasporium strigosum (Pers. ex Fr.) Sacc. is reported by Farr et al. (1989) to occur on rye throughout its range. Although we have found it on other grasses in Virginia we have not encountered it on rye.

Septoria secalis Prill. & Delacr., the cause of rye leaf blotch, is reported by Farr et al. (1989) to have occurred in Virginia. That report traces to Sprague (1950). We have not found the fungus.

Sorghum bicolor (L.) Moench. - grain sorghum.

In Virginia, the acreage of sorghum is relatively small. Like corn, barley, and oats, it is a feed grain in this state. Very few observations have been made on sorghum diseases; most of our records pertain to fungi on sudangrass (*S. vulgare* var. *sudanense* (Piper) Hitchc. and Johnsongrass (*S. halepense* (L.) Pers.). These will be covered in a later paper.

Ascomycotina:

Gibberella fujikuroi (Sawada) Ito & K. Kimura, although a plurivorous grass fungus, is a common cause of sorghum head blight in eastern Virginia. The anamorph, *Fusarium moniliforme* Sheldon, is very conspicuous and is the stage usually seen. We have collected classroom material at the Experiment Station in Holland.

Basidiomycotina - Ustilaginales:

Sporisorium sorghi Link in Willd. causes covered kernel smut. The fungus is seed-borne and hence would be introduced in Virginia on seed stocks. Since the fungus can be eliminated from seeds by fungicides, it has not appeared in recent years. We have only one record of its occurrence, circa 1959, in Montgomery Co. It probably was of common occurrence before 1940.

Basidiomycotina - Uredinales:

Puccinia purpurea Cke. occurs commonly in the southeastern states, and occasionally spores blow northward into eastern Virginia causing isolated outbreaks. Although we observed and identified the fungus from urediniospores on sorghum in test plots at Holland, Va. (Nansemond Co. = City of Suffolk), no herbarium specimens are on file.

Deuteromycotina - Hyphomycetes:

Cercospora sorghi Ellis & Everh. causes gray leaf spot of *Sorghum* spp. Farr et al. (1989) list it from Virginia but we have no collections of it.

Cladosporium herbarum (Pers.:Fr.) Link, leaf mold, and the head blight fungi *Fusarium acuminatum* Ellis & Everh., *F. culmorum* (Wm. G. Sm.) Sacc., *F. equiseti* (Corda) Sacc., and *F. oxysporum* Schlecht.:Fr. are listed by Farr et al. (1989) to occur in the "range of the host", thus, including Virginia. We have no records of their occurrence.

Deuteromycotinia - Coelomycetes:

Macrophomina phaseolina Tassi, the cause of charcoal rot, according to the Agricultural Handbook 165 (Anonymous, 1960), occurs from Maryland to Georgia; however, we have no records of its presence.

Triticum aestivum L. - common wheat

Formerly an important crop in western Virginia, especially the Shenandoah Valley, wheat is now concentrated in the Coastal Plain and Piedmont.

Zygomycotina:

Rhizopus stolonifer (Ehrenb.:Fr.) Vuill., frequently emerges from wheat seeds plated on agar. Farr et al. (1989) call it a "range of host" fungus. It is a plurivorous fungus we have only found associated with wheat and corn seed.

Basidiomycotina - Ustilaginales:

Tilletia caries (DC.) Tul. & C. Tul. and *T. laevis* Kühn in Rabenh., the smooth and spiny-spored bunt fungi, have both occurred throughout Virginia. They were common in wheat until the 1930's when effective seed-treatment fungicides and seed certification programs virtually eliminated them. No recent collections have been made.

Basidiomycotina - Uredinales:

Puccinia recondita Roberge ex Desmaz. is the leaf rust fungus and is common on wheat in Virginia; however, its prevalence may be diminished by production of resistant cultivars. These cultivars usually succumb to rust after a few years of production as virulent races evolve or spread into a region. The spermagonial and

aecial stages occur on several *Thalictrum* spp. which occur in Virginia but apparently, these meadowrue species do not function as aecial hosts in this region.

Deuteromycotina - Hyphomycetes:

Tetraploa ellisii Cooke in Cooke & Ellis, has been observed on wheat leaves from Dinwiddie Co. Spores of *T. ellisii* appeared while leaves were being incubated to induce sporulation of *Pyrenophora tritici-repentis*.

Deuteromycotina - Coelomycetes:

Ascochyta graminea (Sacc.) Sprague & Johnson has been collected from Caroline Co. and two locations in Westmoreland Co. Spores were 14-20 X 4.5-6.0 μm in all collections. Specimens were collected in February, March and early April from overwintered leaves and early spring growth suggesting that the fungus is active in winter. These are new records.

Dilophospora alopecuri (Fr.) Fr. causes twist of grasses. The disease occurred frequently in wheat when the gall nematode *Anguina tritici* (Steinbuch) Filip. was rampant in Virginia, although no biologic relation between the twist fungus and nematodes has been established. Since the 1930's when the nematode was brought under control, it has disappeared from wheat, probably due to improvement of wheat culture. We last collected it in 1959 from Pittsylvania Co., where 70% of the plants had twist.

Septoria tritici Roberge in Desmaz., causes speckled leaf blotch of wheat. It is more common in the Midwest than in Virginia. We have collections from Montgomery and Northumberland Cos.

Stagonospora nodorum (Berk.) Castellani & Germano (known previously as *Septoria nodorum* (Berk.) Berk.) is the most common leaf spotting fungus of wheat in Virginia. It also infects the glumes and nodes; the disease whether on leaves or glumes is called glume blotch. It occurs throughout the state.

Zea mays L. - corn or maize, including dent, pop and sweet corn.

Myxomycota:

Polymyxa graminis Ledingham was listed on corn under plurivorous fungi. However, since there is only an abstract (Roane & Roane, 1983) reporting its presence in corn roots, we reiterate that we identified it in roots from Hanover, Richmond and Sussex Cos. No doubt, it can be found wherever "soil-borne" wheat and oat viruses are present as *P. graminis* is the transmitting agent for them. This includes most of the Coastal Plain and much of the Piedmont.

Mastigomycotina:

Physoderma maydis (Miyabe) Miyabe, the cause of brown spot, occurs from Virginia southward. In Virginia, it occurs primarily in southeastern counties; we have collections from that area in class material.

Pythium aphanidermatum (Edson) Fitzp. has been identified from stalks with a watery soft rot collected in Chesterfield, Mathews, Nelson, and Northampton Cos. between 1941 and 1955.

Zygomycotina:

Absidia sp., *Mucor* sp., *Rhizopus stolonifer* (Ehrenb.:Fr.) Vuill. and *Rhizopus* sp. are listed by Farr et al. (1989) as having been isolated from Virginia corn samples. We have isolated these and *Cunninghamella* sp. (Roane, 1950) at various times during experimental studies of corn seed microflora. *Mucor* and *Rhizopus* are usually found associated with untreated corn seeds and may sometimes interfere with germination.

Ascomycotina:

Chaetomium spp. have been observed on corn seed in agar plating experiments. These fungi are commonly associated with corn (Farr et al., 1989).

Cochliobolus carbonum R. R. Nelson is found on corn leaves, ears and sometimes roots in its anamorphic stage, *Bipolaris zeicola* (G. L. Stout) Shoemaker (= *Helminthosporium carbonum* Ullstrup). It is unusual in that race 1 produces a toxin that severely damages inbred maize lines of the *hm hm* genotype. All above ground parts are affected. The specific epithet was suggested by the charcoal-black kernels produced by ear infections. Although races 2 and 3 also cause kernel blackening, the symptoms are usually restricted to ear-tip kernels. Spots caused by race 1 are circular, whereas those caused by 2 & 3 are elongate and narrow. Races 2 & 3 are widespread in Virginia but more commonly found in the western parts.

Cochliobolus heterostrophus (Drechs.) Drechs. is the teleomorph of *Bipolaris maydis* (Nisik. & Miyake) Shoemaker, a common leaf spotting fungus of corn in southeastern Virginia. In some years it occurs on corn throughout the State. When the fungus was known as *Helminthosporium maydis* Misik. & Miyake, in 1970 it spread from corn in Florida northward into the corn belt states with devastating fury and caused a 15% loss of the national corn crop (Anonymous, 1972, p. 7). This outbreak was predicted by the discovery in 1962 that corn having a cytoplasmic gene that induced male sterility and which facilitated making hybrid corn seed without the arduous task of detasseling was very susceptible to *H. maydis* in the Philippines (Anonymous, 1972, p. 12). Since the sterility gene had been discovered in Texas, it was designated *Tms* (Anonymous, 1972, p. 10). A race of *H. maydis* evolved in the United States that could make a toxin, especially in corn of *Tms* origin. The latter fungus was called *H. maydis* T, to distinguish it from an older race known as *H. maydis* O. Breeders quickly abandoned *Tms* and reverted to detasseling; *H. maydis* T caused little damage in 1971 and virtually none since. Although *H. maydis* T may be isolated today, *H. maydis* O predominates the population. The teleomorph occurs only rarely in nature; it was collected from several plants at the Tidewater Research Station, Holland, in 1949 (Roane, 1950).

Gibberella fujikuroi (Sawada) Ito in Ito & Kimura occurs commonly on fallen, weathered corn stalks throughout Virginia. Farr et al. (1989) list only its anamorph, *Fusarium moniliforme* Sheldon, in their host-fungus list of maize pathogens (p. 431), but in the fungus list (p. 714) acknowledge *G. fujikuroi* as a maize pathogen. It should be the other way around. When hybrid corn varieties were first introduced into Virginia, farmers in the southeastern quarter endured severe stalk breakage epidemics when *G. fujikuroi* rotted out the nodal tissue, then covered the nodes with pink mycelium and spores of the *F. moniliforme* stage (Roane, 1950). The susceptible hybrids were soon discarded in favor of stalk-rot-resistant ones.

Presently, in Virginia, *G. fujikuroi* is a common kernel infecting fungus but it does not cause much stalk rot in commercial corn production.

Massarina arundinacea (Sow.) Leuchtmann, synonym *Leptosphaeria arundinacea* (Sow.:Fr.) Sacc. occurs on one-year-old corn stalks in Montgomery Co. Collections were first made in 1950 from year-old fallen stalks of open-pollinated corn. Fallen hybrid stalks are not as durable as were fallen open-pollination stalks; thus, the fungus has not been found recently. Our original collection was identified by W. W. Diehl, U.S.D.A., Beltsville, Md.

Mycosphaerella zeae (Sacc.) Woronow, = *M. zeicola* Stout, was found on corn leaves in Richmond (1951) and Tazewell (1955) Cos. The fungus developed on leaves having severe phosphorus deficiency symptoms possibly resulting from low soil pH. The fungus was common but not of economic importance.

Odontotrema sp. is listed by Farr et al. (1989) as occurring on corn in Virginia but we could not find the origin of this report. Clements and Shear (1931) illustrate *O. hemisphaericum* (Fr.) Rehm but give no clue as to its habitat.

Setosphaeria turcica (Luttrell) Leonard & Suggs, anamorph *Exserohilum turcicum* (Pass.) Leonard & Suggs (synonym, *Helminthosporium turcicum* Pass.), occurs in the field only in the anamorphic stages. It causes northern leaf blight of corn (a strange common name since it occurs in Central America and other areas of the Tropics) and is common throughout Virginia. Its prevalence and severity are conditioned by the relative susceptibility of hybrid varieties currently in production.

Basidiomycotina - Uredinales:

Puccinia polysora Underw., the southern corn rust fungus, occurs sporadically in Virginia when spores from the South are blown northward. A statewide incidence was observed in 1980; a collection was obtained from Northumberland Co.

Puccinia sorghi Schwein. occurs annually on all types of corn throughout Virginia. It is rarely of economic importance except on late-planted sweet corn which it can defoliate, thereby reducing the quantity and quality of ears. We have collections only from Montgomery Co. The aecial hosts are *Oxalis* spp. which occur in Virginia but we have no records of aecia in the State. The fungus does not parasitize *Sorghum* spp. as the binomial would suggest.

Basidiomycotina - Ustilaginales

Ustilago zeae (Beckm.) Unger, common or boil smut, occurs on all types of corn throughout Virginia. Young galls are edible and American Indians consumed them; they also used black mature galls to make face paints worn during various ceremonies. We have various collections preserved for classroom use.

Deuteromycotina - Hyphomycetes:

Acremonium strictum W. Gams, formerly *Cephalosporium acremonium* Auct. non Corda, causes black bundle disease and Cephalosporium kernel rot of corn. On kernels, very fine parallel stripes may indicate its presence. It is readily isolated from corn samples taken throughout the State. Its presence was first noted in 1950 (Roane, 1950).

Alternaria spp. commonly colonize dead tissues of corn plants. Most probably *A. alternata* (Fr.:Fr.) Keissl. (= *A. tenuis*) is among those present.

Aspergillus spp. are widely distributed and are common contaminants of grain products. Farr et al. (1989) list the following as occurring in Virginia:

Aspergillus candidus Link, *A. flavus* Link:Fr., *A. glaucus* Link:Fr., *A. niger* Tiegh., *A. ochraceus* K. Wilh., *A. parasiticus* Speare, *A. restrictus* G. Sm. and *A. tamarii* Kita. See plurivorous species for comments.

Aureobasidium zeae (Narita & Hiratsuka) Dingley (synonym, *Kabatiella zeae* Narita & Hiratsuka), causes eye-spot disease of corn. We collected it in Montgomery and Orange Cos. in fall of 1984.

Botrytis cinerea Pers.:Fr. causes ear and seed rot of corn. It has been isolated from kernels of various origin in Virginia (Roane, 1950).

Cercospora sorghi Ellis & Everh. is listed by Farr et al. (1989) as occurring on corn in Virginia. We have found it only on *Sorghum* spp.

C. zeae-maydis Tehon & Daniels, the cause of gray leaf spot, was first observed in Virginia in Montgomery Co. in 1949 (Roane, 1950). With the production of so-called "no-till" corn, in which the crop residue is left on the soil surface, gray leaf spot has become a major disease of corn production in the United States. At present, it is widespread in Virginia.

Chalara sp. is listed by Farr et al. (1989) as occurring on corn in Virginia. That report is attributed to C. L. Porter (1927) who isolated the fungus from nodal tissue.

Nigrospora sphaerica (Sacc.) Mason, causes ear rot of corn and is widely distributed but of sporadic occurrence. It is often isolated from grain samples. Gray cob rot is caused by this fungus.

Penicillium spp. cause blue mold, blue-eye, and green molds of corn ears. *Penicillium chrysogenum* Thom, *P. expansum* Link, and *P. oxalicum* Currie & Thom. are verified as occurring in Virginia. Farr et al. (1989) list 30 species (probably isolated from kernels or meal) associated with corn. Hence our list is very minimal. *Penicillium* spp. are among the earliest colonizers of fallen ears.

Periconia spp. are associated with roots and kernels of corn. We have encountered *Periconia* only twice but did not determine the species. Both materials were from Hanover Co. in 1983. Farr et al. (1989) list only *P. circinata* (Mangin) Sacc. as associated with corn root rot.

Spegazzinia tessarthra (Berk. & Curtis) Sacc. produces small black colonies with spiny spores. It is reported by Farr et al. (1989) to occur in Virginia; we could not find the origin of the report.

Stachylidium bicolor Link:Fr., has been found on prop roots of corn from Hanover Co. in 1981. This is a new report for this fungus in Virginia.

Trichoderma viride Pers.:Fr. causes a green ear rot and is widespread but uncommon on ears from upright plants; it is a frequent colonizer of fallen ears. We have isolated it from many sources. Numerous ears of hybrid Va. 556 from Pittsylvania Co. were colonized by *T. viride* in 1960.

Trichothecium roseum (Pers.:Fr.) Link is listed by Farr et al. (1989) as occurring in Virginia. The report is attributed to Porter (1927) who isolated it from nodal tissue of stalks; however, he did not specifically identify the state from which the fungus was collected.

Deuteromycotina - Coelomycetes:

Dinemasporium strigosum (Pers.:Fr.) Sacc. [synonym, *D. graminum* (Lib.) Lév.]

was collected on one-year-old stalks in Montgomery Co., July, 1957. Undoubtedly, it is a saprophyte. Neither *D. strigosum* nor its teleomorph, *Phomatospora dinemasporium* Webster, are listed by Farr et al. (1989) as occurring on maize.

Diplodia maydis (Berk.) Sacc. causes ear and stalk rot and is widespread in Virginia. The taxonomy of this fungus is confusing. Its older name was *D. zeae* (Schwein.) Lév.; Sutton (1980) places *D. zeae* in the taxon *Stenocarpella maydis* (Berk.) Sutton but does not mention *D. maydis* as a separate taxon or synonym. The treatment of *Diplodia* and *Stenocarpella* requires additional consideration by mycotaxonomists. Spores of *D. maydis* are 25-30 X 6 μm.

Diplodia macrospora Earle [*Stenocarpella macrospora* (Earle) Sutton] has been found by us on a single ear collected at Holland circa 1952 (when Suffolk was Nansemond Co.). The ear is in our classroom collection. Spores from this specimen measure 65-82 X 6-8 μm, much longer than those of *D. maydis*.

Phyllosticta sorghina Sacc. was collected on leaves from corn growing at Warsaw, Richmond Co., Aug., 1951. Spore dimensions were 2.5 X 5.0 μm, different from other species known on corn.

Deuteromycotina - other:

Sclerotium rolfsii Sacc., the cause of southern blight of many plants, is listed by Farr et al. (1989) on corn in Virginia. The origin of the report is not known. We have not collected this fungus on corn.

SUMMARY

The fungi annotated in the text are listed alphabetically below. Their hosts are signified by the first letters of the common names of the hosts, i.e., B = barley, C = corn, O = oats, R = rye, S = sorghum, and W = wheat.

Absidia sp. - C
Acremonium strictum = *Cephalosporium acremonium* - C
Alternaria alternata - B C O R S W
Ascochyta brachypodii - B O
A. graminea - W
A. hordei - B R W
A. sorghi - B R W
Aspergillus candidus - C W
A. flavus - C W
A. glaucus - C W
A. niger - C W
A. ochraceus - C
A. parasiticus - C
A. restrictus - C
A. tamarii - C
Aureobasidium zeae = *Kabatiella zeae* - C
Botrytis cinerea - C
Cercospora sorghi - C S
C. zeae-maydis - C
Chaetomium spp. - C
Chalara sp. - C

Cladosporium herbarum - B C O R S W
Claviceps purpurea - B R W
Cochliobolus carbonum = *Bipolaris zeicola* - C
C. heterostrophus = *B. maydis* - C
C. sativus = *B. sorokinianum* - B W
C. victoriae = *B. victoriae* - O
Colletotrichum graminicola - B C O R W
Cunninghamella sp. - C
Dilophospora alopecuri - W
Dinemasporium strigosum - C R
Diplodia macrospora = *Stenocarpella macrospora* - C
D. maydis = *Stenocarpella maydis* - C
Dreschslera graminea - B
Epicoccum nigrum - B C O R S W
Erysiphe graminis - B O R W
Exserohilum turcicum - C
Fusarium acuminatum - S
F. avenaceum - O
F. culmorum - S
F. equiseti - S
F. oxysporum - S
Gaeumannomyces graminis - B W
Gibberella fujikuroi = *F. moniliforme* - C S
G. zeae = *F. graminearum* - B C R W
Heterosporium avenae - B C O R S W
Hymenula cerealis - R W
Macrophomina phaseolina - S
Massarina arundinacea - C
Mucor sp. - C
Mycosphaerella zeae - C
Nigrospora sphaerica - C
Odontotrema sp. - C
Penicillium chrysogenum - C
P. expansum - C
P. oxalicum - C
Periconia sp. - C
Phaeosphaeria avenaria - O(?)
Phyllosticta sorghina - C
Physoderma maydis - C
Polymyxa graminis - B C O R W
Puccinia coronata - O
P. graminis - B O R W
P. hordei - B
P. polysora - C
P. purpurea - S
P. recondita - W
P. sorghi - C

Pyrenophora avenae = *Drechslera avenae* - O
Pyrenophora teres = *D. teres* - B
Pyrenophora tritici-repentis = *D. tritici-repentis* - R W
Pythium aphanidermataum - C
Rhizoctonia solani = *Thanatephorus cucumeris* - B O W
Rhizopus stolonifer - C W
Rhynchosporium secalis - B R
Sclerophthora macrospora - B C O W
Sclerotium rolfsii - C
Septoria passerinii - B
S. secalis - R
S. tritici - W
Spegazzinia tessarthra - C
Sporosorium sorghi - S
Stachylidium bicolor - C
Stagonospora nodorum = *Septoria nodorum* - W
Tetraploa ellisii - W
Tilletia caries - W
T. laevis - W
Trichoderma viride - C
Trichothecium roseum - C
Urocystis occulta - R
Ustilago avenae - B O
U. hordei = *U. segetum* - B O
U. nuda - B R W
U. zeae - C

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ARTICLE I: NAME

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ARTICLE II: PURPOSE

The purpose of this organization shall be to establish and maintain in Virginia for scientific and educational purposes an association of persons and organizations interested in science and scientific research in all of its branches; to solicit financial and other support; to cooperate with educational institutions, industries, and state agencies in fostering an interest in scientific matters, in promoting scientific investigations and in spreading knowledge of the sciences; to provide a forum for the presentation and discussion of papers on scientific subjects and facilities for their publication; to provide opportunities for the cooperation and fellowship among its members; and generally, in doing these things, to benefit not only its own members, but to promote the civic, agricultural, academic, industrial, and commercial welfare of the people of Virginia.

ARTICLE III: ORGANIZATION

Section 1. Membership

Membership in this organization shall be open to professional scientists of all branches of science and others who are interested in the purpose of the organization. Types of membership and dues for each shall be specified in Academy Bylaws. The membership, through the Academy Conference, provided by Section 2 of Article VIII, shall have ultimate authority over the affairs of this organization.

Section 2. Sections

The Academy shall be organized into Sections according to the various scientific disciplines. A person may belong to one or more Sections in accordance with his or her interests.

Section 3. Council

The governing body of this organization shall be the Academy Council. Its composition and responsibilities are specified in Article VII.

Section 4. Officers

The elected officers of this organization shall be a President, a President-Elect, a Vice President, a Secretary, and a Treasurer. Duties of each shall be specified in Academy Bylaws.

Section 5. Executive Committee

The elected officers, the immediate past president and the Director of the Junior Academy of Science shall comprise the Executive Committee of the Academy Council.

Section 6. Standing Committees

The primary activities of this organization shall be implemented by Standing Committees as follows: the Research Committee, the Long Range Planning Committee, the Junior Academy of Science Committee, the Membership Committee, the Finance and Endowment Committee, the Trust Committee, the Publications Committee, the Awards Committee, the Fund Raising Committee, the Nominations and Elections Committee, the Virginia Flora Committee, the Science Advisory Committee, the Science Education Committee, the Archives Committee, the Committee on the Environment, and the duties of the Standing Committees not specified hereafter, shall be as specified in the Academy Bylaws, and as may be further enumerated by Council from time to time.

ARTICLE IV: THE VIRGINIA JOURNAL OF SCIENCE

The Virginia Journal of Science shall be the official publication of the Virginia Academy of Science. All Academy members shall receive copies of this publication.

ARTICLE V: FELLOWS

From active membership, there shall be a body of scholars known as "Fellows of the Virginia Academy of Science" selected because of their contribution to science in one or more of the following ways: (a) outstanding scientific research, (b) inspirational teaching of science, (c) significant leadership in the Academy. Rules and procedures for selection of Fellows shall be specified in the Academy Bylaws.

ARTICLE VI: ACCREDITATION OF MEMBERSHIP

Membership of the Academy shall be accredited by the Secretary and the Treasurer. The membership list shall be published periodically according to types, as directed by Council.

ARTICLE VII: COMPOSITION AND RESPONSIBILITIES OF COUNCIL

Section 1. Council shall be composed of the President, the President-Elect, the Vice President, the Secretary, the Treasurer, the three most recent Past Presidents and one member elected by each Section of the Virginia Academy of Science. Members from the Sections shall be elected for three year terms on a rotational basis among the Sections, provided the initial term of a member from a newly established Section shall be specified by Council. In addition to the foregoing, the Chairs of the Standing Committees, the Editor of *The Virginia Journal of Science*, the Editor of *Virginia Scientists*, the official Academy Representative to the Board of Trustees of the Science Museum of Virginia, the official representative of the Academy to the American Association for Advancement of Science and National Association of Academies of Science, the Director of the Visiting Scientists Program, and the Director of the Virginia Junior Academy of Science shall be members of Council. In event of vacancies, the President shall make interim appointments until the next election is held; provided however, vacancies of elected officers shall be filled as hereafter provided.

Section 2. Council shall meet each year preceding the annual meeting and at least once in the fall at a time and place designated by the President.

Section 3. Twelve members shall constitute a quorum for the transaction of business by Council.

Section 4. Council shall establish the policies of this organization and shall be responsible for the administration of all Academy funds.

Section 5. Council shall consider and recommend to the membership from time to time appropriate changes in the Constitution, and shall promulgate bylaws appropriate to the implementation of the Constitution.

Section 6. Council may establish appropriate administrative positions and employ such personnel as may be required. Terms of office, the duties and remuneration of such personnel shall be prescribed by Council.

Section 7. Through appropriate Bylaws, Council shall provide for the publication of *The Virginia Journal of Science* and the *Virginia Scientists*.

Section 8. The Executive Committee of Council shall be empowered to act for Council on an interim basis between meetings of Council and shall report to Council at its regular meetings. A meeting of Council may be called at any time upon concurrence of any four members of the Executive Committee.

ARTICLE VIII: MEETINGS AND BUSINESS

Section 1. The annual meeting of this organization shall be arranged in accordance with procedures to be established by Council in appropriate Academy Bylaws.

Section 2. All business requiring action by the membership shall be transacted at an Academy Conference, which shall be scheduled by Council during the annual meeting. A meeting of the Academy Conference may be called between Annual Meetings by concurrence of a majority of the members of Council; provided, however, that the membership shall be notified of such called meeting no less than thirty (30) days prior to the date that such meeting is to be held. Forty accredited members shall constitute a quorum for the transaction of business by an Academy Conference.

Section 3. Each Section shall annually arrange a program oriented to its area of scientific interest; provided, however, such programs shall be compatible with the purpose of the Academy and scheduled within the framework of the general meeting program of the Academy.

Section 4. The fiscal year of the Academy shall be from January 1 through December 31.

Section 5. The parliamentary procedure for all meetings of this organization shall be governed by Robert's Rules of Order Revised, and Council shall provide for a Parliamentarian.

ARTICLE IX: ESTABLISHMENT OF SECTIONS

Section 1. Sections as defined in Article III with the approval of Council, may be organized by an accredited group of members. Each Section shall annually arrange a scientific program related to its area of interest.

Section 2. Such a Section may become accredited and established after it has conducted one successful program at an annual meeting of the Academy.

Section 3. Any Constitution and Bylaws changes proposed by a Section must conform to the provisions of the Academy Constitution and Bylaws and shall be submitted to Council for review and approval prior to adoption by Section.

Section 4. Any Section which fails to conduct a program at two successive Academy annual meetings, may be dropped as a Section by action of Council; but, may be reinstated after subsequently conducting one successful program.

Section 5. When established, all Section names shall be enumerated in the Academy Bylaws, and thereby subject to provisions of Article XIII, Section 1.

ARTICLE X: ELECTION OF ACADEMY AND SECTION OFFICERS

Section 1. A "Nominations and Elections Committee" consisting of three recent Past Presidents, appointed by the President, shall establish a slate of nominations for the positions of President-Elect, Vice President, Secretary, and Treasurer and conduct an election for same in accordance with procedures specified by Academy Bylaws.

Section 2. Upon election, officers shall serve one-year terms commencing at the annual meeting at which their election is announced and continuing until the next annual meeting; provided, however, the President-Elect shall automatically ascend to the position of President at the end of this scheduled term of office and at any prior time that the office of President may be vacated; however, such person shall not serve as President beyond the term that such person was originally scheduled to serve as President.

Section 3. All interim vacancies in Academy offices, other than President, occurring between annual Academy Conferences, shall be filled by Council from names of persons recommended by the Executive Committee. Persons so selected shall serve until the next Academy Conference.

Section 4. Each Section shall elect from their members:

A. A Chair and a Secretary for one-year terms of office.
B. A Representative to Council in accordance with the provisions of Article VII.
C. Other officers desired.

Section 5. Persons to fill vacancies in Section offices which occur between Annual Meetings shall be designated by the Council Representative from that Section.

Section 6. All Elected officers shall serve without remuneration, but, at the discretion of Council, may be reimbursed for certain expenses incurred in conducting the business of the Academy.

ARTICLE XI: COMMITTEE STRUCTURE, APPOINTMENTS, TERMS, ETC.

Section 1. Except as provided otherwise, all Standing Committees shall be composed of three (3) or more members, and the President shall designate Committee Chairs, and appoint approximately one-third of the members of each Committee for terms of three (3) years, and shall subsequently appoint members to fill unexpired terms that occur periodically.

Section 2. The Research Committee shall be composed of five (5) members, each appointed for a term of five (5) years. One new member shall be appointed each year by the President to replace the member whose term expires; unexpired terms shall also be filled by appointment by the President. The senior member of the Committee shall be Chair.

Section 3. A Trust Committee, composed of three (3) accredited members, shall be elected by Council, to serve for terms of three (3) years on a rotational basis. The members of this Committee shall place in trust and supervise the management of Academy investments subject to annual review by Council. The Committee shall elect its own Chair; provided, however, that should it be unable to do so, the President shall name the Chair.

Section 4. The President and Council shall assign operational matters to appropriate Standing Committees; however, the President and/or Council may establish Special Committees as the need arises.

ARTICLE XII: JUNIOR ACADEMY OF SCIENCE

The Academy shall provide financial support, leadership, and supervision to a Junior Academy of Science. Effective working relationships shall be maintained with such Junior Academy of Science, through the Junior Academy of Science Committee.

ARTICLE XIII: BYLAWS AND AMENDMENTS

Section 1. Council shall promulgate appropriate Bylaws to implement or further clarify the Articles of this Constitution. The establishment or amendment of such Bylaws shall require an affirmative vote of a majority of the total membership of Council; provided, that all proposed Bylaws or amendments shall be distributed to the membership or published in an issue of *The Virginia Journal of Science* at least thirty (30) days prior to action by Council.

Section 2. This Constitution may be changed or amended, after the recommendation of a majority of the total membership of Council, by a two-thirds majority of an Academy Conference, provided all proposed changes shall be submitted to members of Council in writing no less than fifteen (15) days prior to the Council Meeting at which such proposals are to be considered and further provided that subsequent to approval by Council, all proposed amendments shall be published in *The Virginia Journal of Science* or distributed in writing to the membership no less than twenty five (25) days nor more than fifty (50) days prior to presentation to an Academy Conference for adoption.

Section 3. All provisions of the Constitution and Bylaws in effect prior to the adoption of this Constitution, except the provisions of this Article, shall rule until new Bylaws are duly established in accordance with Section 1 of this Article.

ARTICLE XIV: ARTICLES OF INCORPORATION

The Articles of Incorporation of this organization (Charter) shall conform to the provisions of this Constitution and all amendments hereafter adopted. The Constitution and Bylaws Committee shall review and coordinate all necessary appropriate revisions of both documents and be responsible for the submission of all required reports to the State Corporation Commission and other governmental entities, annually or as otherwise required by law.

ARTICLE XV: DISSOLUTION OR LIQUIDATION

Section 1. In the event of dissolution or liquidation, all liabilities and obligations of the Academy shall be paid, satisfied and discharged.

Section 2. All assets remaining, including those received and held for scientific and educational purposes, shall be transferred to one or more societies or organizations engaged in activities substantially similar to those of the Academy; provided however, that no assets shall accrue to the benefit of any officer or member of the Academy.

BYLAWS OF VIRGINIA ACADEMY OF SCIENCE

ARTICLE I: TYPES OF MEMBERSHIP AND DUES

Section 1. There shall be nine types of members: regular, student, contributing, sustaining, life, patron, honorary life, business, and emeritus.

Section 2. Dues of the first four types of members shall be as follows:

A. Regular members shall pay annual dues of twenty-five dollars ($25.00).
B. Student members shall pay annual dues of ten dollars ($10.00).
C. Contributing members shall be individuals who elect to pay annual dues of thirty dollars ($30.00).
D. Sustaining members shall be individuals who elect to pay annual dues of fifty dollars ($50.00) or more, and institutions which shall pay annual dues of one hundred dollars ($100.00) or more.
E. To be in good standing the foregoing types of members must pay the specified dues by July 1.

Section 3. Life members shall be individuals who elect to pay to the Academy the sum of three hundred dollars ($300.00) and thereby become exempt from further payment of dues.

Section 4. Patrons shall be those persons who have given to this organization the sum of one thousand dollars ($1,000.00) or its equivalent in property. They shall have all the rights and privileges of Regular Members and shall be exempt from dues. An institution may also become a Patron by meeting the above requirement. Its representative shall have all the rights and privileges of regular members.

Section 5. Honorary Life members shall be persons elected by the Council for long and distinguished service to science. They shall have all the rights and privileges of Regular Members and shall be exempt from dues. Previous active membership in this organization shall not be a requirement of eligibility.

Section 6. Business or industrial organizations, which elect to pay dues of one hundred dollars ($100.00) annually, shall be Regular Business Members of the Academy, or may elect to:

A. Pay annual dues of three hundred dollars ($300.00) and be designated Contributing Business Members, or
B. Pay annual dues of five hundred dollars ($500.00) and be designated Sustaining Business Members.

Section 7. Emeritus Members shall be persons who have been active Academy members for at least ten years and retired from full-time employment. These Members shall have all rights and privileges of regular membership but will be exempt from dues. Eligibility for Emeritus membership status will be determined by requests to the Membership Committee.

ARTICLE II: DUTIES OF OFFICERS

Section 1. The President shall be the directing head of the Academy, shall preside at business meetings and general sessions of the organization, and shall appoint the members of the standing committees and of new committees authorized by the Council, in accordance with Article XI of the Constitution.

Section 2. The President-Elect shall assist the President as mutually agreed between them and shall serve as President in the latter's absence. The President-Elect shall furnish the Editor of *The Virginia Journal of Science*, in time for publication with the Summer issue of *The Virginia Journal of Science*, a list of committee memberships which he or she has set up to assist him or her during his or her year as President . The President-Elect shall distribute that list to Council at the Annual Meeting at which he or she automatically ascends to President. The President-Elect begins a three year term serving as a member of the Finance and Endowment Committee.

Section 3. The Vice President shall be responsible for coordinating the scientific programs of the Annual Meeting. The Vice President shall serve as a member of the Membership Committee.

Section 4. The Secretary shall be responsible for keeping complete records of the Academy Conference and all meetings of the Council and Executive Committee.

Section 5. The Treasurer shall:

A. Account for the income and disbursements through one Academy General Fund Account.
B. Keep the membership lists of the Academy up-to-date.
C. Upon request, supply the Secretary and others a list of all members in good standing.
D. Receive and disburse all funds as approved by Council and directed by the President or Chair of the Finance Committee and Endowment Committee.
E. Submit to Council annually a written report of all receipts and disbursements, accompanied by a statement of audit from a certified public accountant.

F. Furnish quarterly financial summaries to the Executive Committee, members of Council, and to members of the Finance Committee.
G. Prepare annually and present to the Finance and Endowment Committee for review a proposed budget for Academy operations.

Section 6. The Treasurer and all administrative employees engaged in the receipt and disbursement of funds shall be adequately bonded.

Section 7. All officers shall be ex-officio members of all Academy Committees.

ARTICLE III: DUTIES OF STANDING COMMITTEES

Section 1. The Research Committee shall:
A. Review and award Academy Research Grants.
B. Arrange for and present the J. Shelton Horsley Research Award.

Section 2. The Long Range Planning Committee shall:
A. Develop and advise Council on broad policies which will affect the Academy in the future.
B. Solicit and study suggestions from the membership for the improvement of Academy activities.
C. Investigate and evaluate proposed projects, publications and other factors that may relate to the long-range effectiveness of the Academy.
D. Advise and consult with other Academy Committees relative to the aforegoing and make recommendations to such committees concerning the effectiveness of their various activities.

Section 3. The Junior Academy of Science Committee of the Virginia Academy of Science shall:
A. Assist the Executive Committee in selecting a Director and an Associate Director for the Virginia Junior Academy of Science.
B. Coordinate with the Director activities of The Virginia Junior Academy of Science including development, expansion, and the annual meetings.
C. Review funding proposals for the Virginia Junior Academy of Science and submit appropriate recommendations to the Executive Committee or other designated committees in a timely manner.
D. Publish and distribute *Proceedings of Virginia Junior Academy of Science*.
E. Select student representatives and alternates to attend The American Junior Academy of Science.
F. Solicit membership and participation in Virginia Junior Academy of Science programs and projects.
G. Support and participate in all other programs and activities related to the work of Virginia Junior Academy of Science.

H. Set up procedures for selecting the top students and declare and announce them to be State Winners in the Virginia Science Talent Search, and all other contestants as runners-up.
I. Carry out other duties that support the development of science in education as approved by Council.

Section 4. The Membership Committee shall:
A. Make recommendations to Council, the Executive Committee and officers relative to policies on general membership.
B. Promote membership growth and seek adequate representation from all scientific disciplines.
C. Sponsor a Business Advisory Committee for the purpose of creating understanding between science and business, and to solicit business memberships to the Academy.

Section 5. The Finance and Endowment Committee shall:
A. Monitor and appraise income and expenditures, and make appropriate recommendations to the President, Executive Committee and Council.
B. Estimate annually the anticipated income of the Academy and prepare a proposed budget for consideration by Council at its Fall meeting.
C. Seek and encourage the establishment of endowments to the benefit of Academy activities.
D. Have at least one member of this Committee be a member of the Trust Committee.

Section 6. The Trust Committee shall:
A. Place in trust and supervise the management of funds of the Academy designated by Council or otherwise for investment.
B. Review all Academy investments annually and make appropriate adjustments subject to approval of Council.

Section 7. The Publications Committee shall:
A. Develop and implement a continuing policy of review and evaluation of Academy publications.
B. Present to Council annually through the Finance Committee the budgetary needs of the several Academy periodical publications.
C. Make recommendations to Council relative to priority, publication, finance and distribution of non-recurring publications.
D. Select and recommend to Council, as necessary; an Editor for the *Virginia Journal of Science*, and members of the editorial Board.
E. Enlist the interest of all groups in worthwhile publications by the Academy.

Section 8. The Awards Committee shall:

A. Select recipients of the Ivey F. Lewis Distinguished Service Award to be presented periodically to a member who has made significant contributions toward the activities of the Virginia Academy of Science.

B. Select recipients of Special Awards periodically as directed by Council.

C. Accept and submit to Council nominations for fellows in accordance to Article V of the Constitution and Article V of the Bylaws.

Section 9. The Fund Raising Committee shall:

A. From time to time at the direction of Council, plan, organize, and coordinate appropriate fund raising campaigns in support of Academy activities or projects contingent to the purposes of the Academy.

Section 10. The Nominations and Elections Committee shall:

A. Mail to the membership on or about January 1 each year a request for nominations of persons to fill the offices of President-Elect, Vice President, Secretary and Treasurer.

B. Nominate a slate of one person for each of the aforenamed offices and present report to Council for informational purposes.

C. Mail slate of nominees to members advising that names may be added to the slate by 25 members petitioning the committee on behalf of each name to be added.

D. Prepare ballots with or without additional nominees as the case may be and mail to membership with registration and other information relative to annual meeting indicating deadline and address for return of ballot to committee.

E. Count ballots and announce results at the Academy Conference. Should a tie vote result for any office, the Academy Conference shall vote on the nominees. In all cases, the nominee receiving the largest number of favorable votes shall be elected; provided, however, that only members in good standing may cast ballots.

Section 11. The Constitution and Bylaws Committee shall:

A. Periodically receive and prepare drafts of all proposed changes in constitution as the occasion arises and present same to Council and membership for consideration as set forth in the constitution.

B. Draft all Bylaw changes as directed by Council and notify membership of such changes.

C. Update articles of Incorporation (Charter) as required.

D. Provide a Parliamentarian for all Council meetings and Academy Conferences.

Section 12. The Virginia Flora Committee shall:

A. Promote the study of and publications of the flora and vegetation of Virginia.

B. Sponsor symposia and conferences on the ecology, conservation, and preservation of the plant life of Virginia.

C. Disseminate botanical information to all who are interested in the flora and ecology of Virginia.

D. Serve as liaison between the Academy, government bodies, and institutions in matters pertaining to the plant life of Virginia.

Section 13. The Science Advisory Committee Shall:

A. Provide scientific and technical information and advice requested by the Executive, Legislative, and other governmental bodies and agencies of the Commonwealth of Virginia.

B. Serve as liaison for the collection and transfer of scientific information and/or advice solicited in (A).

C. Collect and evaluate suggestions and opinions regarding topics of general public interest wherein science and technology may provide assistance, but where such assistance has not been requested. The Science Advisory Committee will make recommendations to the Academy, to the Executive Committee, and/or the Council of the Academy for review and approval. The Science Advisory Committee, upon direction of Council or Executive Committee, shall serve as a conduit for placement of such information before the appropriate Executive, Legislative, or other governmental body or agency.

D. Maintain an inventory of scientific interests and expertise of individuals within the Academy who are willing to serve in an advisory and/or consultant capacity to state government.

E. At no time operate beyond constraints considered as proper conduct for a non-profit organization.

F. Append all reports and recommendations with a statement as follows; "The Virginia Academy of Science assumes no legal or financial responsibility for the utilization or dispersal of scientific and technical data or advice provided by the science Advisory Committee, further, the Academy assumes no responsibility, financial or other-wise, to governmental agents or agencies, institutions, individuals or committee members pursuant to the conduct and activities of this Committee."

Section 14. The Science Education Committee shall:

A. Promote science education in the State of Virginia.

B. Disseminate information about scientific matters and scientific topics of current interest.

C. Respond to requests for assistance in matters dealing with education in the areas of mathematics and science, such as are embraced by the various Academy Sections and as directed by the President and Council of the Academy.

D. Assist and cooperate with the Virginia State Department of Education in planning and conducting the annual State Science Teachers Conference, K-12. Delegated members of the Committee may hold and be responsible for funds generated by the activities of the State Science Teachers Conference, solely for the purpose of funding the Conference meetings. These funds shall remain separate from other funds of the Academy.

Section 15. The Archives Committee shall:

A. Address the business of collection, assembly, organization, cataloguing and storage of records, documents, awards and paraphernalia associated with the history and development of the Academy.
B. Secure an institutional repository for storage of the inactive records of the Academy.
C. Secure the services of a qualified individual to establish and maintain the aforementioned records, as the official Archivist of the Academy; and such person shall be extended honorary membership in the Academy.
D. Assist, and cooperate, with the Archivist in securing and screening of records and documents destined for permanent storage in the Archives.

Section 16. The Committee on the Environment shall:

A. Maintain close liaison with organizations and agencies involved in environmental study and management.
B. Keep informed of the status of Virginia's environment, noting particularly those problems and issues amenable to scientific research.
C. Cooperate with the Science Advisory Committee in advising and providing information to private and public environmental agencies and bodies.

ARTICLE IV: THE VIRGINIA JOURNAL OF SCIENCE

Section 1. The Academy shall publish *The Virginia Journal of Science* quarterly.

Section 2. The staff of *The Virginia Journal of Science* shall be composed of:

A. An editor recommended by the Publications Committee and appointed by Council for a three-year term.
B. Such Associate Editors, Assistant Editors, or Editorial Board Members, appointed by the President, as are recommended by the Editor and the Publications Committee.
C. Editors designated by individual Sections.

Section 3. All members of the Academy shall receive *The Virginia Journal of Science*.

Section 4. Subscriptions may be sold to non-members at a rate established by the Publications Committee and approved by Council.

ARTICLE V: RULES AND PROCEDURES FOR SELECTING FELLOWS

Section 1. A Fellow must be nominated by at least three members of the Academy. The Academy Council must approve each Fellow by a majority vote. It will be the usual procedure to announce new Fellows at an Annual Meeting.

Section 2. Nominations for Fellows with appropriate biographical information shall be sent directly to the Executive Secretary-Treasurer annually prior to October 1. All information received shall be forwarded to the Chair of the Awards Committee for review and recommendations to Council prior to the subsequent Annual Meeting. All nominees not recommended by the Committee or not acted upon favorably by Council shall remain in consideration for one additional year.

Section 3. No more than twenty-five fellowships will be approved the first year. After the first year, no more than one-half of one percent of the total active membership shall be selected in any one year. The limiting number of Fellows shall not exceed five percent of the total active membership of the Academy. However, nothing in this section shall preclude the election of one Fellow each year.

Section 4. All Fellows shall be presented with a suitably inscribed scroll.

Section 5. Appropriate announcement of new Fellows shall be made in *The Virginia Journal of Science*.

ARTICLE VI: THE DULY ORGANIZED SECTIONS OF THE ACADEMY

The duly organized scientific sections of the Academy are:

(1) Agriculture, Forestry, and Aquaculture
(2) Astronomy, Mathematics, and Physics
(3) Microbiology and Molecular Biology
(4) Biology
(5) Chemistry
(6) Materials Science
(7) Biomedical and General Engineering
(8) Geology
(9) Medical Sciences
(10) Psychology
(11) Education
(12) Statistics
(13) Aeronautical and Aerospace Sciences
(14) Botany
(15) Environmental Science
(16) Archaeology
(17) Computer Science
(18) Geography
(19) Natural History and Biodiversity

ARTICLE VII: OFFICIAL REPRESENTATION OF THE ACADEMY

Section 1. Where official representation of the Academy is desirable, the President, the President's designees, or an official representative appointed by Council shall represent The Academy.

Section 2. No Officer or Academy Member shall receive reimbursement from Academy funds for such purposes except as included in the annual budget of the Academy or separately approved by Council from available funds.

Section 3. The official representative to serve as delegate to the American Association for the Advancement of Science (AAAS) shall be appointed by Council for a term designated by the AAAS. Actual expenses of the official representative in attending the Annual Meeting of AAAS may be paid if the funds are included in the budget or separately approved by Council.

Section 4. The official representative to serve on the Board of Trustees of the Science Museum of Virginia shall be recommended by Council and serve as an ex officio member of Council. Actual expenses of the official representative may be paid if the funds are included in the budget or separately approved by Council. Expenses payable by the Board or Science Museum of Virginia shall not be reimbursed by the Academy.

ARTICLE VIII: MEETINGS AND BUSINESS

The annual meeting of this organization shall be held in the Spring of each year at a time and place selected by Council, which shall arrange for all appropriate sessions.

ARTICLE IX: EXECUTIVE SECRETARY-TREASURER

Section 1. The position of Executive Secretary-Treasurer is hereby established for the purpose of providing administrative assistance to the officers and committee chairs.

Section 2. The Executive Committee shall select a qualified person for this position, specify his or her duties, and set appropriate remuneration which shall be approved by Council.

Section 3. The incumbent of this position shall serve at the pleasure of the Executive Committee, subject to review by Council.

Section 4. The incumbent of this position shall attend all Council and Executive Committee Meetings and may participate in all deliberations as circumstances dictate, but, shall not have a vote in either body.

ARTICLE X: VISITING SCIENTISTS PROGRAM DIRECTOR

Section 1. The position of Visiting Scientists Program Director is hereby established for the purpose of implementing a Visiting Scientists Program in cooperation with the State Board of Education.

Section 2. The Executive Committee upon recommendation of the President shall select a qualified person for this position and approve guidelines for the conduct of the program.

Section 3. The incumbent of this position shall serve at the pleasure of the Executive Committee, subject to review by Council.

ARTICLE XI: THE DIRECTOR OF THE VIRGINIA JUNIOR ACADEMY OF SCIENCE

Section 1. The position of Director of the Virginia Junior Academy of Science is hereby established for the purpose of providing leadership, supervision, and administrative support to the Virginia Junior Academy of Science and the Junior Academy of Science Committee.

Section 2. The Executive Committee, subject to the approval of Council, shall select a qualified volunteer for this position.

Section 3. The incumbent of this position shall serve at the pleasure of the Executive Committee subject to review by Council.

Section 4. Duties of the Director of the Virginia Junior Academy of Science.

A. The Virginia Junior Academy of Science Director shall provide leadership, supervision and administrative support to the Virginia Junior Academy of Science.

B. The Virginia Junior Academy of Science Director shall be a member of The Virginia Academy of Science, shall attend all Council and Executive Committee meetings and may participate in all deliberations.

C. The Virginia Junior Academy of Science Director shall prepare an annual budget for the Virginia Junior Academy of Science and submit the Virginia Junior Academy of Science budget with Virginia Junior Academy of Science Committee recommendations to the Academy Finance and Endowment Committee by September 1.

D. The Virginia Junior Academy of Science Director shall coordinate all fund raising by the Virginia Junior Academy of Science with the Fund Raising Committee, The Trust Committee, and The Finance and Endowment Committee.

E. The Virginia Junior Academy of Science Director shall be responsible for the program of Virginia Junior Academy of Science at the annual meeting of the Academy and coordinate Virginia Junior Academy of Science activities with the Virginia Academy of Science Program Chair.

F. The Virginia Junior Academy of Science Director shall be responsible for the development and expansion of the Virginia Junior Academy of Science as approved by Council.

G. The Virginia Junior Academy of Science Director shall serve as Chair the Junior Academy of Science Committee with the approval of the President.

H. The Virginia Junior Academy of Science Director shall carry out other duties specified by the Virginia Junior Academy of Science Committee or the Executive Committee as approved by Council.

ARTICLE XII: ASSOCIATE DIRECTOR OF THE VIRGINIA JUNIOR ACADEMY OF SCIENCE

Section 1. The position of Associate Director of the Virginia Junior Academy of Science is hereby established for the purpose of providing administrative assistance to the Junior Academy of Science Committee, the Chair of the Junior Academy of Science Committee and the Director of the Virginia Junior Academy of Science.

Section 2. The Executive Committee, subject to the approval of Council, shall select a qualified person for the position, specify his or her duties, and set appropriate remuneration, if any.

Section 3. The incumbent of this position shall serve at the pleasure of the Executive Committee, subject to annual review by Council and by the Junior Academy of Science Committee.

Section 4. The incumbent of this position shall be a member of the Virginia Academy of Science, attend all Council meetings and all Virginia Junior Academy of Science Committee meetings, and may participate in all deliberations as circumstances dictate, but shall not have a vote in either body.

ARTICLE XIII: VIRGINIA SCIENTISTS NEWSLETTER

Section 1. The Virginia Academy of Science shall publish periodically the *Virginia Scientists* as its newsletter.

Section 2. The staff of the *Virginia Scientists* shall be composed of:

A. An Editor recommended by the Publications Committee and appointed by Council for a three-year term.

B. Such Associate Editors, Assistant Editors, or Editorial board Members, appointed by the President, as are recommended by the Editor.

Section 3. The Editor shall serve on the Publications Committee and on Council.

Section 4. All members of the Virginia Academy of Science shall receive the *Virginia Scientists*.

ARTICLE XIV: OFFICIAL ABBREVIATIONS

Section 1. The official abbreviation for the Virginia Academy of Science shall be **VAS**.

FUTURE MEETINGS
AND
CHAIRS OF LOCAL ARRANGEMENTS COMMITTEES

73rd VAS...54th VJAS...May 23-26, 1995

Virginia Military Institute, Lexington, Virginia

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Virginia Military Institute, Lexington VA 24450
703-464-7503 (O)

Richard B. Minnix, Department of Physics and Astronomy,
Virginia Military Institute, Lexington VA 24450
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(For list of Committee Members in charge of scheduling, registration, exhibits, etc.; see **Special Committee on Local Arrangements** listings.)

74th VAS...55th VJAS...May 1996

Virginia Commonwealth University, Richmond, Virginia

Thomas W. Haas, Director, Cooperative Graduate Engineering Program
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75th Anniversary of The Virginia Academy of Science
56th VJAS...May 1997
Virginia Polytechnic Institute and State University
Blacksburg, Virginia

76th VAS...57th VJAS...May 1998

George Mason University, Fairfax, Virginia

George W. Mushrush, Department of Chemistry,
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77th VAS...58th VJAS...May 1999

Old Dominion University, Hampton, Virginia

(NOTE: Academy Central Office, Publications, and other frequently used addresses and phones are listed on the inside back cover.)

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1994-95 ACADEMY COUNCIL ELECTED OFFICERS

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I. J. Good and
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J. H. Burness 1973
Kuldip P. Chopra 1974
Roddy V. Amenta 1975
Douglas W. Ogle and
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Henry W. Gould 1977
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William L. Dewey 1979
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R. J. Huggett 1980
L. E. Jarrard 1981
Joyce G. Foster, ... 1982
Harold E. Burkhart, and
Peter T. Sprinz 1983
R. W. Berlien, G. Colmano, and
G. Nunn 1984
Milton M. Sholley,
Gilda P. Ferguson,
Hugo R. Seibel,
James L. Montour, and
John D. Wilson 1985

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W. John Hayden 1991
(not awarded)
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Research Laboratory 1958
Lloyd C. Bird ∞ 1959
No Award 1960
No Award 1961
No Award 1962
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No Award 1964
Hiram R. Hanmer 1965

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No Award 1972
No Award 1973
Lynn D. Abbott, Jr. 1974
Edward S. Harlow 1975
D. Rae Carpenter, Jr. 1976
No Award 1977
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Edward F. Turner, Jr. ∞ . . . 1979
Ruskin S. Freer ∞ 1980
Philip Morris, Inc.
(Presented to
Bernard Kosakowski) 1981

Carolina Biological
Supply Company 1982
No Award 1984
Arthur W. Burke, Jr. 1985
Virginia C. Ellett 1985
Vera B. Remsburg 1986
No Award 1987
No Award 1988
Ertle Thompson 1989
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William T. Sanger ∞

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Wilbert Harnsberger, Jr. ∞
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Paul B. Siegel

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1982
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1983
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Dallas W. Cocke ∞
R. Dean Decker
Mario R. Escobar ∞
Charles O'Neal
Martha L. Walsh ∞

1984
Dawn Campbell ∞
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J. J. Murray
Stewart Ware

1985
Edward A. Crawford

1986
No Fellows Elected

1987
No Fellows Elected

1988
No Fellows Elected

1989
Kenneth R. Lawless

1990
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1991
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1992
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1993
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1994
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